STARTPAGE

HUMAN RESOURCES AND MOBILITY (HRM) ACTIVITY

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PART B

STAGE 2

CONFORMAL STRUCTURES AND DYNAMICS

"CODY"

CONTENTS

SECTION 1 – SCIENTIFIC QUALITY

SECTION 2 – TRAINING AND TRANSFER OF KNOWLEDGE

SECTION 4 – MANAGEMENT AND FEASIBILITY

TEAMS:

Team 1.	**UK**	**University of Warwick**	**Sebastian van Strien**
Team 2.	**Warsaw**	**Warsaw/IMPAN**	**Feliks Przytycki**
Team 3.	**Finland**	**University of Helsinki**	**Kari Astala**
Team 4.	**France**	**Université d'Orléans**	**Michel Zinsmeister**
Team 5.	**Spain**	**Universitat de Barcelona**	**Nuria Fagella**
Team 6.	**Germany**	**University of Kiel**	**Walter Bergweiler**
Team 7.	**Denmark/Sweden**	**RUC**	**Carsten Lunde Petersen**
Team 8.	**Greece**	**TEI of WM**	**Antonios Bisbas**
Team 9.	**Switzerland**	**Université de Génève**	**Stanislav Smirnov**

Conformal Structures and Dynamics (CODY)

The research aim of the proposed training network: "Conformal Structures and Dynamics" is to understand **local self-similar structure of fractal spaces, objects or processes, by methods of space-time conformal rescaling.** The investigations and the subject of the training programme of the proposed network will therefore be contained in three closely related fields of mathematics and mathematical physics whose common denominator is the notion of conformal or quasiconformal structure: mathematical (conformal) analysis and geometric measure theory, conformal and low-dimensional dynamics, continuum scaling limits of physical processes. The strength of this proposal lies in the potential interaction and cross-fertilization between these fields and potential applications (image and data analysis). The proposed EU wide network will address the fragmentation of the research teams and integrate the research topics across the disciplines of mathematics and physics.
In order to achieve this aim, the training network aims to offer 252 person/month appointments as ESR's and 168 person/month appointments as ER's, and to provide a training programme organised following unifying themes and methodology outlined below.

SECTION 1 – SCIENTIFIC QUALITY

1.1 The teams participating in this proposal

The proposed network includes 9 teams and in particular the majority of European specialists in holomorphic iteration theory and several top groups of scientists in parts of analysis and mathematical physics, to provide a highly professional yet multidisciplinary training in the mathematical techniques involved. Each of the teams has tremendous strength in at least one of the three relevant research areas - Conformal Analysis and Geometric Measure Theory (A), Conformal Dynamics (D), Topics in Mathematical Physics (P).
The **United Kingdom [1]** team at Warwick, which has made significant contributions to (A,D) and has extensive experience in leading European networks (ESF Prodyn, LOCNET, UniNet,…), will coordinate the network. The **Polish [2]** team is among the strongest in the entire field of mathematics from all the new EU member states, and will include departments in Warsaw and the remainder of Poland. The **Finnish [3]** team is probably the world leader in (A). The Field medallist Yoccoz is included in the **French [4]** team which has made profound contributions in (A,D,P). The **Spanish [5], German [6]** and **Danish/Swedish [7]** teams all have hugely contributed to (A,D). The **Greek [8]** team has particular experience in Fractals, while the **Swiss [9]** team has made striking contributions in (A,D,P). The network comprises one Fields medallist, one Wolf Prize medallist, four Salem Prize winners and many other outstanding experts in the field. In Section 1.3 contributions made by members of these teams will be highlighted by the number of the team they belong to.
The geographic fragmentation and the diversity of backgrounds of these teams forms an impediment. Although in some subtopics, some of the teams are already world-leaders, by integrating these teams in a network and by crossing the somewhat unnatural boundaries between research fields, it is possible to create a world-class research group with the quality and potential for delivering new breakthroughs which might otherwise not be feasible. The inclusion of a very strong team from Warsaw and the Greek team located in Makedonia provides an excellent opportunity to attract young researchers from these less favoured regions of Europe. By co-operating with several scientists from Brazil, Chile,

Russia, Ukraine, USA, Canada, Japan and China we plan to attract gifted young researchers from many parts of the world.

1.2 Non-technical description of the research area

Dynamical systems is a major mathematical discipline, born with H. Poincaré's "Les méthodes nouvelles de la méchanique céleste" at the end of XIX century. It describes global space-time behaviour of orbit structure of (deterministic) processes: flows and iterated transformations. In recent decades its methods have been influencing and often dominating many areas in ordinary and partial differential equations and differential geometry. Many investigations have been encompassed by the general Thom-Smale-Palis programme, to study typical dynamics and prove that in many situations most of the space typically consists of basins of attraction to periodic motions, to describe separating chaotic sets and study changes of the patterns with changing parameters. **Inside dynamical systems we focus on the branch called iteration of holomorphic maps** and make excursions and links to 1-dimensional real iteration, higher (but still low) dimension, iterated function systems and Kleinian groups. Much progress has been made on these topics, with Europe playing an important role. However, to stay leading, it is crucial to make full use of the expertise by creating an EU network.
The theory of holomorphic iteration was created by Fatou and Julia in the beginning of XX^{th} century. The field was dormant until its modern revival inspired by computer experiments, exhibiting fascinating "*fractals*" (popularized and named so by Mandelbrot). At the beginning of the eighties Douady[4], Hubbard[4] and Sullivan applied the powerful analytical tools of quasiconformal mappings, in particular the measurable Riemann mapping theorem of Ahlfors-Bers-Bojarski[2]-Morrey about homeomorphic solutions of Beltrami equations. Parallel to this development, hyperbolic geometry was recognized as a fundamental tool to uniformize surfaces, via the notion of discrete groups of isometries which brings dynamical systems into the picture; Teichmüller theory, that is the theory of deformations of hyperbolic Riemann surfaces, became also used (here for deformations of rational maps). The similar study of hyperbolic three-manifolds lead to the Mostow-Rigidity theorem whose key ingredient is a regularity property of quasiconformal mappings. Simultaneously Feigenbaum developed the theory of renormalization. These ideas culminated with McMullen's unification of exponential convergence of renormalizations and Thurston's geometrization theorems. Another spectacular development has been linearization theory with achievements by Bryuno, Herman, and Yoccoz[4], related to KAM theory of *quasiperiodic* motions alternated with "*chaos*" in celestial mechanics.
Fractals and their equilibrium (Gibbs) measures are studied with the help of ergodic theory and finer tools from probability theory. This yields a feedback to analysis: boundary behaviour of univalent functions (fine multifractal structure of harmonic measures) can be studied by dynamical methods.
More recently, the relation between physics and conformal geometry was exploited in conformal field theory and critical lattice models. Physical intuition and the use of (conjectural) conformal invariance of the lattice models led to striking predictions of dimensions and exponents for percolation, Brownian motion and other models. Then tools from complex analysis (including the Loewner differential equation) allowed many of these predictions to be confirmed. Complex analysis also emerged in the study of many other stochastic models (diffusion limited aggregation, random matrices etc.).
Conformal extensions to the complex plane allow one to understand iteration of maps of interval, the kernel of dynamics in higher dimension. These iterations model biological, ecological, chemical, and atmospheric and many other processes, often through infinite dimensional systems. There is a feedback with classical (and modern) function theory and a spectacular drift towards rigorous mathematical models of infinitesimal limits of physical processes. The mathematical insight in "chaotic" dynamics,

deformations and fractals will lead young researchers, guided by leading European (and some of other countries) scientists to a deep understanding of complex systems in physics, chemistry, biology (neurobiology, cardiology) to the more applied levels (nonlinear analysis of experimental time series e. g. of an electrocardiogram for diagnosis purpose), and through contacts with industry to influence development of technology.

1.3 Scientific objectives and description of the state-of-the-art

We detail the research objectives according to three themes and sub themes that constitute the horizontal structure of the network. These objectives have been chosen for their importance in the different research areas, but also for their "transversal" character through the themes. Several objectives classified below in Analysis or Dynamical Systems (A and D) could be put in Mathematical Physics, for example Multifractal Analysis (A3). The research objectives listed here are mainly in mathematics and mathematical physics, however they have many applications to industry, banking, social sciences, medicine, biology etc.
We provide a brief outline of the state-of-the-art in each field and list experts involved in the proposed network (putting in parenthesis the number of the node in which the cited expert participates, numbered according to the forms A2 of the application). The network includes the majority of the European specialists in holomorphic iteration theory and several top groups of scientists in the relevant parts of mathematical analysis and mathematical physics. We expect a substantial contribution by these experts towards advances in the field, training and transfer of knowledge. We outline also novel concepts and methods to be applied.

A. Conformal Analysis and Geometric Measure Theory

A1. Conformal structures, analytic and geometric background and view, Objective: *A systematic study of mappings with finite distortion. quasiconformal mappings in metric spaces, applications to limit sets in dynamics and ideal boundaries. Development of analytic tools for Carnot-Caratheodory spaces for metric study of IFS limits.*
Here the goal is to apply features (e.g. quasisymmetry) from the classical Ahlfors-Bers theory to a more general setting and to higher dimensions, see Iwaniec[2] and Martin and Koskela[3]. In this direction, David[3] managed to solve Beltrami equations where the dilatation is allowed to be infinite on a small set of points leading several applications to dynamics by Haissinsky[4], Petersen[7] and Zakeri. A second goal is to extend the Euclidean theory to this new geometric situation, inspired by the work of Heinonen and Koskela[3] on Loewner spaces (characterized by the existence of Poincaré inequalities). Analysis in Carnot-Caratheodory spaces (Reimann[9], Balogh[9] has applications in geometric control theory, robotics and non-holonomic mechanics with huge potential for industrial applications. Thirdly, Gromov showed that Mostow's ideas applied to the wide class of hyperbolic groups, leading to the study of quasisymmetric maps and invariants of ideal boundaries, a class of spaces which are very far from being manifolds, see Paulin, Pansu[4], Kaimanovitch[6] and Pajot[4]. We propose an approach, in the specific case of Kleinian groups, by thermodynamical formalism.

A2**.** Potential theory, analytic tools. Objective: *Description of analytically and quasiconformally removable sets, applications to Julia sets and rigidity in holomorphic dynamics. Investigations towards the Painlevé and Brennan conjecture.*
During the past decade many interesting relations have been found between rectifiability properties of sets and measures, behaviour of singular integral operators, and removable singularities of bounded analytic and Lipschitz harmonic functions, by Mattila[3], Melnikov, Verdera, David[4], Jones and

Smirnov[9] and their co-workers. Another promising approach is to study the harmonic measure through approximation by equilibrium measures for conformal IFS (see D2, D5). It was understood recently, due to the work of Makarov, Jones, and Carleson[7] and others, that many important problems in complex analysis reduce to describing the fine structure of harmonic measure. There are indications that extremal behaviour is attained for Fatou domains, and then one can apply thermodynamical formalism to estimates (compare A3 and D3), as was done by Binder, Makarov and Smirnov[9]. A third source of expected progress is application of holomorphic motions (which figure prominently for planar quasiconformal maps, compare A1, and complex dynamical systems, compare D2), as was done by Astala[3] in the related problem of dimensional distortion by quasiconformal maps.

A3. Topics in Fractals and Multifractal Analysis (see also A2, P1-2 and themes D). Objectives: *Construct a general theory, involving projection and intersection schemes. Derive a comprehensive multifractal description of new classes of measures emerging from deterministic processes.*
Recently, breakthroughs were achieved in multifractal formalism by Falconer[1], Olsen[1], Mattila[3], O'Neil and others. The presence in the network of the best specialists in conformal and non-conformal, analytical, dynamical and physical setting is therefore a great bonus. In higher dimensional non-uniformly hyperbolic setting, new methods by Bareira, Schmeling[7], and Pesin (proving the Eckmann[9]-Ruelle conjecture) are promising, see also A2 and D5. Some results on geometric-like (McMullen's) measures for non-conformal IFS have been achieved already (Gatzouras[8], Baranski[2]). Large Eddy Simulations (LES) models for turbulence based on the Iterated Function System (IFS) formalism have first been investigated by Scotti and Meneveau. Oliver [6] has worked on averaging closures in particular applications in geophysical fluid dynamics, on porous medium flow, and is currently working on the approximation theory of IFS. A promising and yet currently used tool is indeed the multifractal analysis of data recorded from out-of-equilibrium complex systems (atmospheric and hydrodynamic turbulence, combustion reactions, biological systems) and multifractal analysis of electrocardiograms in the purpose of diagnosing heart pathologies.

D. Conformal Dynamical Systems

D1. Iteration of interval and circle maps, and their complexification, weak hyperbolicity and physical measures. Objective: *The real Fatou conjecture and the Thom-Smale-Palis objective.*
Progess on density of hyperbolicity, universality of scalings in renormalization have been phenomenal (Yoccoz[4] – Fields medal in 1994, Swiatek[2], Graczyk[4], Sands[4], Levin[2], van Strien[1], Lyubich, Sullivan, McMullen -- Fields medal in 1998). Recently the full rigidity theory for maps of the interval and the circle and density of hyperbolicity (when almost all points are attracted to attracting periodic orbits) was proved by Kozlovski[1], Shen and van Strien[1] (this is often called real Fatou conjecture - an interval case of Thom-Smale-Palis objective, see Section 1.2)). However the problem of strange metric attractors and the complex Fatou conjecture are still wide open (but the existence of quadratic maps with Julia sets of positive measure is now established through the exiting recent work of Buff[4]-Cheritat[4]-Douady-Shishikura). Related to this is the question whether for most parameters these systems have physical measures.

D2. Geometry of dynamical and parameter space. Objective: *Improve the understanding of the rich geometry of both dynamical and parameter spaces, including the interplay between the two, for various families of rational or holomorphic maps in one complex variable.*
It is not known, even for the family of complex quadratic polynomials, if hyperbolicity is generic. It would be implied by the so-called MLC conjecture: the Mandelbrot set M, i.e. the connectedness locus of the quadratic family, is locally connected. Substantial progress (many parameters at which M is

locally connected) has been achieved by Yoccoz. This conjecture has counterparts in the dynamical plane: which Julia sets are locally connected? Finding a proof of the Yoccoz theorem which extends to more general situations would give a deeper insight (there are important recent developments by Kahn and Lyubich (and Kozlovski[1], Shen and van Strien[1] in the multicritical case)).

D3. Hausdorff measure and dimensions. Objectives: *Determine the conformal measures for various classes of Julia sets. Understand the periodic orbits and dynamical Zeta-function, compare P2.*
The hyperbolic theory was extended over the last years, by Denker[6] and Urbanski[2] in the parabolic case and by Graczyk[4] and Smirnov[9] for the weakly summable case. The theory of weakly recurrent transcendental maps is also developing. Spectacular results by McMullen and Karpinska[2] on support of dimension in Julia set (Cantor bouquet) are being followed by Schleicher[6]. Also Stallard[1], Rippon[1] and Jarque[4] have made remarkable contributions. The complete description of conformal measures has been done in this case; based on an idea of Urbanski[2], it permitted McMullen, Douady[4], Sentenac[4] and Zinsmeister[4], to study continuity properties of Hausdorff dimension in the quadratic family. The conformal measures concept should be explored further.

D4. Limit sets for Kleinian groups and relations. Objectives: *Understanding conformal measures supported on "deep" points. Find restrictions on rational maps via equivalence relations, more subtle than affine laminations, being a counterpart for the extension of the action of a Kleinian group to the bal.*

D5. Beyond dimension 1. Objectives: *Prove a "no wandering domain" theorem for Hénon mappings; Find a decomposition of the dynamical space analogous to the Yoccoz puzzle. Explore the parameter space for the famous Hénon maps corresponding to non-uniformly hyperbolic analogues of solenoids.*
Carleson[7] and Benedicks[7] have shown that the set of Hénon maps with a strange attractor has positive measure. Benedicks[7], Yoccoz[4], Luzzatto[1] have been working to make progress in understanding real Hénon attractors. Hubbard[4] has explored the topology and geometry of Hénon maps and other families of mappings in complex two-dimensional space. This is a field where almost nothing is known: CODY aims here to develop the beginning theory of complex two-dimensional Hénon-maps and to determine the Hausdorff dimension of Julia sets.

D6. Iterated Function Systems (IFS). Objectives: *Improve the understanding of IFS with overlap and the Hausdorff and packing measures of limit sets (see A3). Determine the dimension of sets of parameters with defected dimension of the limit set or singular probability distribution in the "fat" case. Study infinte IFS's (*arising *in renormalization techniques D1,D2).*

P.Topics in Mathematical Physics (see also A3)

P1. Scaling limits in physical processes. Objectives: *Build a bridge between the probabilistic approach to random growth processes and conformal field theory in fixed and in fluctuating geometry. We expect progress in rigorous foundations for renormalization and universality for 2D critical lattice models. Extend research in other random models, where complex analysis plays an important role: Diffusion Limited Aggregation (a generic model of fractal growth), random matrices (of major importance in studying disordered media), etc. Make progress in the study of Schramm-Loewner Evolution and various lattice models (Ising, dimer models, SARW).*
Recently there was significant progress in the mathematical understanding of random conformally invariant objects in the plane. Following introduction by Schramm of the Stochastic Loewner Evolution, Lawler, Schramm, and Werner proved Mandelbrot's conjecture on the dimension of the

Brownian frontier being 4/3, established values of Brownian intersection exponents predicted by the physicist Duplantier[4], and constructed the scaling limit for the Loop Erased Random Walk. The predictions of the physicist Cardy[1] have been proved for the critical percolation on triangular lattice by Smirnov[9], who also showed convergence of its interfaces to Schramm's SLE curves. The presence of leading scientists of this field at the border of mathematics and physics opens the possibility to exploit the new methods and interactions for a significant progress. This is an exceptionally dynamic research field, interdisciplinary and scientifically profound.

P2. Infinite dimensional systems. Objective: *Study coupled map lattices and more general infinite dimensional systems*
Bricmont[4] and Kupiainen[3] have shown the existence of SRB measures with exponential decay of correlations for coupled map lattices. Baladi[4], Isola, Degli-Espositi, Jarvenpaa[3], and Kupiainen[3] studied the transfer operator in the Bricmont-Kupiainen[3] example. The recent contribution of Rugh[4], who introduced a natural Banach space for the transfer operator of weakly coupled analytic circle maps is remarkable. This was followed by a joint work of Baladi[4] and Rugh[4], and has been inspiring (G. Keller[6], Schmitt, Jarvenpaa [3]) similar constructions for weakly coupled interval maps. These and results by Liverani and others provides a framework to understand (and quantitatively describe) entropy production out of equilibrium, that is to give a microscopic rooting to the irreversible thermodynamics.

P3. Turbulent transport. Objective: *Explore IFS approximations not only for modelling passive transport in synthetic turbulence but also for other transport phenomena of practical importance: high Reynolds number flow and porous medium flow in multiscale materials.*
Rough models of passive turbulent transport based on random dynamical systems permit to understand the basic phenomena like occurrence of cascades of conserved quantities, and presence of intermittency characterized by anomalous scaling laws and multifractality. However, IFS techniques have not been sufficiently explored in this area and any progress will open up new avenues.

1.4 Research methodology and originality: transversal connections

The purpose of the proposed training network is to reinforce the research strength of each of the participating nodes by nurturing and developing some natural "transversal connections". These connections – all centred around the theme of conformal structures - will be the guiding principles in the organization of the research and the way the training programme will be set-up, and can be described as follows:
Quasiconformal surgery. This has turned out to be an extremely powerful tool in geometry and dynamical systems, and was made possible by extremely sophisticated analytical tools. Experts of the network continue investigating the field; in particular "trans"-quasiconformal surgery seems to be a very promising direction of research, and analysts have started a systematic study of mappings with finite distortion.
Parabolic implosion. This key phenomenon discovered by Douady appears to be a fundamental tool in understanding what happens for a family of conformal dynamical systems at a parabolic bifurcation. It is fundamental for the study of the discontinuities that occur there. It is also more and more clear that this phenomenon could explain the existence of polynomials with positive measure Julia sets. Moreover it interests also the physicists through the notion of phase-transition or intermittent behaviour. Training and development of this field will thus also be a priority.
Renormalization techniques. This is the paradigm of a method, which has developed through

multidisciplinarity. Initiated by physicists, it was considerably developed by mathematicians both in the real and complex settings and it happens now to be at the heart of many conjectures of the fields, as the generic hyperbolicity or MLC. It constitutes also another possible route to positive area Julia sets. Renormalization also plays an important role in the investigation of conformally invariant stochastic objects, and it is believed to be the origin of universality phenomena for lattice models. We aim to continue the development of this active field further exploiting its multidisciplinary character and active interaction between physicists and mathematicians.

Thermodynamic formalism. This is another extremely powerful tool from physics that concerns basically each subject of the network. Mathematical physicists will help others by their knowledge of the transfer operators while holomorphic dynamics will constitute a field of experimentation for their various properties; naturally new facts about conformal measures and thus the geometry of Julia sets will follow. The formalism is also present through symbolic dynamics, with applications to geodesic flows and number theory, and more generally in ergodic theory. This tool also includes dynamical Zeta functions, a very powerful tool in mathematics and mathematical physics. Thermodynamic formalism (especially in conjunction with multifractal analysis and fractal approximation) is also applied to extremal problems for univalent mappings and harmonic measure.

Harmonic analysis. From quasiconformal mappings to rectifiability properties of sets, from Poincaré inequalities to spectral theory of the transfer operators, analysis is ubiquitous, and techniques such as maximal functions, Littlewood-Paley theory or singular integrals will be encouraged in this network.

Probabilistic methods. These concentrate mainly on Markov models and are extremely important in the field covered by the network. Either they enter explicitly into the picture as in the lattice models or Schramm-Loewner Evolution, or they implicitly enter the picture through ergodic theory, large deviations and multifractal formalism.

A large proportion of breakthroughs in mathematics happen on interfaces between disciplines. Through training programmes centred on the transversal connections above, a fertile environment can be created with common research themes. Although very challenging, one can be very optimistic that many of the above mentioned objectives can be achieved, in view of the amount of recent progress. But the chance of success will be hugely enhanced by creating new opportunities of contact between research teams and disciplines. This will ensure that the critical mass in the highly specialized, but at present sometimes fragmented teams is reached. By having a training programme organized along the above themes, we also can make sure that new insights that lead to progress in one area will cross-feed into other research areas.

1.5 Work plan and deliverables

Organization of major events (for more detail see Sections 2.2.4 and 7).

1. Within months of the start of the network, there will be an opening conference in Warwick on *Conformal Structures and Dynamics. The current state-of-art and perspectives.*
2. Within 12 months, the first annual workshop in Genève. *Perspectives in conformal structures and fractals in mathematical physics*.
3. Within 24 month, a midterm conference, reporting on progress in all the tasks with presentations by young researchers (Warsaw)
4. Within 36 months there will be a third annual workshop, Warsaw on *Real and complex 1-dimensional dynamics*.
5. Within 48 month, Final conference in Paris. *Reports on realization of all the tasks*.

Research time table/deliverables

1. 24 months. Geometry of measures and multifractal analysis (non-uniform or non-conformal scaling).
2. 24 months. Optimal/sharp regularity and removability results for mappings of finite distortion. Progress in analytic removability.
3. 24 months. New integrability conditions, advances in surgery in holomorphic dynamics.
4. 36 months. Description of weakly hyperbolic maps of interval amd holomorphic/transcendental mappings of sphere. Conformal measures, exponents of Poincaré series and dimensions.
5. 36 months. Differentiability (analyticity) of pressure in univalent or holomorphic dynamics setting, description of phase transitions, dynamical zeta-function. Results on probabilistic properties of invariant measures.
6. 36 months. New estimates (computation) of Hausdorff, hyperbolic and box dimension of Julia (-Lavaurs) sets (and special subsets) for parabolic, infinitely renormalizable (other bifurcating classes) of rational and transcendental maps and limit sets under action of semigroups/relations.
7. 36 months. First results on conjecturally conformally invariant lattice models: critical Ising, 4-state Potts, possibly other. Establishing of the existence of some scaling limits. Results on multifractal properties of arising clusters.
8. 48 months. A comprehensive description of Hénon maps in real and complex case. Fixed points for renormalization in dynamical systems case and the case of lattice models in statistical physics. Two complex variables methods in the description of extremal behaviour of conformal maps and fine structure of harmonic measure in the planar domains.
9. 48 months. Comprehensive description of hard classes of interval circle and holomorphic maps; completion of Palis programme in dimension 1.

The tasks A1-3, D1-6, P1-2 mentioned above will be delivered according to the diagram below

	Task A1	Task A2	Task A3	Task D1	Task D2	Task D3	Task D4/D6	Task D5	Task P1-3
1.(UK)			X	X	X	X	X		X
2.(Pol)	X	X	X	X	X	X	X	X	
3.(Fin)	X	X	X						X
4.(Fr)	X	X	X	X	X	X	X	X	X
5. (Sp)			X	X	X				
6.(Germ)	X		X	X	X	X	X	X	
7.(D/Sw)	X	X	X		X	X	X		X
8.(Gr)	X	X	X						X
9.(Swiss)	X	X	X			X			X

SECTION 2 – TRAINING AND TRANSFER OF KNOWLEDGE

2.1 The objective of the network

"Mathematics is, in contrast to other fields, a subject where individual contributions are substantial for progress and go in directions one can never clearly foresee. However, where a network is really useful in mathematics is for the training for young people. In having a network, we can offer them regular meetings where they can measure their capacities against other young people, being guided by a more eclectic choice of subjects than those they encounter in their everyday work."
After the 80s with progress in applying quasiconformal methods in holomorphic iteration, the theory culminated in the mid 90s with spectacular results, when a large spectrum of mathematical techniques were developed and implemented. Researchers in analysis, holomorphic iteration, Kleinian groups, etc. were meeting at joint conferences exchanging ideas. In recent years however the involved branches grew and the area has become fragmented, again, into branches of analysis, separate topics in dynamical systems, and fractals. The absence of any unifying network has negative effects and makes it painful to guide young researchers in the field to reach international standards. For further success it is necessary to join efforts to unify this scientific area again and to include some topics in mathematical physics which have gained momentum in the recent years. This requires multidisciplinary training to educate a new generation of international researchers, disseminating the knowledge between centres, overcoming their tendency to become specialised in rather narrow fields.
Also we need to overcome regional fragmentation. Some teams are highly specialized in one area, but do not have the ability or critical mass to organise training in the range of research areas which are needed for future needs. To promote effective collaboration among scientists from different countries, we want to overcome highly specialized research in some institutions by organizing a wide ranging training scheme.

2.2 The proposed training and Transfer of Knowledge programme

Training activities will be provided vertically, "transversally" through the scientific objectives, emphasizing methods rather than concentrating on individual theories. The network will offer 252 ESR and 168 ER months, see section 2.3.

2.2.1 Training methodology

Career developments plans will be drawn for each trainee so that the precise training package will be tailored to each individual's needs, see Section 2.2.2. The methodology to achieve the general and specific scientific objectives will be through

- Long (usually 1 semester, often split in two) stays of early stage and appointed, more experienced researchers in the nodes of the network, learning through special courses, tutoring, together with local PhD students, and performing research in local teams and in working groups, reinforced by secondments between teams. The role of a local supervisor (and network supervisor, if different person) will be fundamental, see Section 2.2.2.
- Short (1-2 weeks) visits of senior scientists from one node (or from outside the network) to another node, giving intensive courses and providing lecture notes.
- Short visits of recruited researchers, of up to a month.
- Joint mathematical weekends, see Section 2.2.1.

- Summer schools with courses for ESR's, accompanied by exercises and tutorials by the more experienced young researchers, in complementary themes (for example harmonic analysis, harmonic measure on Julia sets, conformal invariance of scaling limits of physical processes). These could take place as part of the planned workshops or conferences.
- Small theme workshops mainly for more experienced researchers, with invited expert speakers, providing an occasion for them to undertake joint work and to present their results.
- Two larger (interdisciplinary) workshops (after 1st and 3rd year)
- Organization of three international conferences (opening, midterm and final).
- Use the network web site as a bulletin board to advertise various openings, meetings schools and conferences, as well as to provide a directory for members of the network, to post questions to the scientific community in Conformal Structures and Dynamics, and to find and deposit preprints.
- Publication of lecture notes from seminar schools, workshop talks and courses and preprints (also using the web page).

2.2.2 Individual training: the best research training is to actually do the research.

- Each researcher will have both a **mentor** and a local **scientific supervisor** assigned (both appointed jointly by the Executive Committee and the local Steering Committee, see Section 4.2.2). The organisation of the individual training at the site place is the responsibility of the local supervisor in collaboration with the Team Leader for that node. We expect experienced researchers to collaborate and accompanied by experts, involve early stage researchers.
- Upon appointment, the ER/ESR will, together with the personal mentor and scientific advisor, draw up a personal **Career Development Plan** (taking his/her career plans into account). This is to ensure that the *most appropriate* training is identified for each individual at the start of his/her tenure in the network and also that it is delivered.
- A supervisor is appointed at each institution visited during secondments (possibly prompted by close collaborative work of the supervisors). The ER's could undertake some shorter visits in order to transfer knowledge to the ESR's.
- Moreover we plan to encourage young scientists to broaden their education and research by **collaborations** with scientists not involved directly in the network, inside and outside the host institution (other departments and universities in the area), and also in the fields of science not directly related to the topic of the network (see also training in complementary skill further on).
- **Information will be exchanged** inside the network, to create opportunities for meetings and discussions, and to promote collaboration. This will help all researchers of CODY to feel they are part of the same collective effort, and to acquire a broad scientific culture. This will benefit in particular young researchers, and prepare them for their teaching and research duties once they get a permanent position.
- All young researchers are encouraged to **register** with the network (through the network office). They will be kept informed of all network activities and job opportunities.

2.2.3 Training in teams

Each team will have a **network seminar** (typically meeting weekly) at its home institution, involving local PhD students and post docs, in all the themes of the network. If some field of the network is missing in the team, the guidance will be provided by **visits of experts from other teams**. Also **Joint Weekend Meetings** (of groups which are geographically close enough) will be organised.

2.2.4 Training and Transfer of Knowledge on network-wide basis: the principle of leverage
Each of the participating partners (nodes) will organise a school and most also a workshop. In addition, there will be three major conferences and four larger workshops. The organisation of these will be delegated to the partners, but specific aspects of the network training plan will be imposed by the network as deliverables for each of these events. In order to have maximal effect, an important principle that the network will use is that of funding network activities within other scientific activities (which also are funded from elsewhere). Specifically, the idea is to often organise schools and workshops as part of non-network conferences, to specifically fund young researchers and to co-fund activities conditional on them having the multidisciplinary character described in Section 1. Through this **leverage** we obtain a **multiplier effect**, so that the philosophy of the network training (through transversal themes as described in Section 1.4) can be applied much more widely and effectively.

A. Schools. The schools will have a multidisciplinary character, with 3-5 complementary (5-10 lectures each) courses with exercises led by experienced researchers. However one topic will dominate (the given task(s) in parentheses below) to make them slightly focused to organize seminars helping in individual research. Altogether we plan about 10 schools (the size depending on the demand and availability of additional funding**).** Examples of such workshop plans (in the research topics A1-P3 from Section 1.3) are

- (D1-3) *Topics in complex dynamics*, Barcelona, spring 2007
- (A1-3) *Recent trends in conformal structures*, in collaboration with Dance (a Spanish network), spring 2008
- (A2, D2) *Analysis on metric spaces and quasi conformal structures*, Bedlewo, Poland, 2009. Polish and Finnish teams
- (A3, D3-4, D6, P1-3) *Fractals and multifractal structure, random growth models, topics in turbulence,* in Greece.
- (D6) *Towards higher dimension*, Göttingen, 2009.
- (A3-5, D3-4, P1) *Potential theory in dynamical setting and random growth models*, in DTU or KTH.
- (A1-3, P1-3*) Les Diablerets, mathematical physics*, 2010 organized by the Swiss Team.

Some, schools will take place as part of other events, such as (✳) (D1-3) *Number theory and dynamical systems*, in Scuola Normale Superiore de Pisa (15/04/07-15/07/07) (Scientific committee Marmi, Margulis, Sarnack, Zagier, Marmi, Yoccoz), (✳) (A1-3) *the Lars Ahlfors Centennial Celebration*, Helsinki 2007, (✳) (D1-6) *Low dimensional dynamics (for the occasion of Misiurewicz' 60th birthday) 2008-2009*, Warsaw.
In addition, at least half of these schools will have attached to them a **one or two-day event** '*towards industrial applications*' (specific topics are already envisaged).

B. Workshops (6 small and 2 larger) and **C. Conferences.** (3 conferences with 80-100 participant, or larger if there is additional funding, taking place in Warwick, Warsaw and Paris), see also Sections 1.6 and 7. Specific events envisaged are

- Within months of the start of the network, there will be an *opening conference* in Warwick and *Conformal Structures and Dynamics. The current state-of-art and perspectives.*
- Within 12 months, the first annual workshop in Paris/Genève. *Perspectives in conformal structures and fractals in mathematical physics*.
- *Aspects of transcendental dynamics*, Bremen 2008, (organized by Bremen, Kiel, Warsaw and Barcelona)
- A midterm conference, reporting on progress in all the tasks with presentations by young researchers (Warsaw)

- After three years, a workshop in Warsaw on *Real and complex one-dimensional dynamics*.
- Final conference in Paris. *Conformal Structures and Dynamics II. Reports on realization of all the tasks*.

Several proposals for workshops on 'towards industrial applications' will be discussed in the first steering committee meeting of the network, and at least one workshop will be focused on this theme whereas other workshops/conferences will have '*towards industrial applications*' events.

2.2.5 Participation and presentation

Schools will be organised with intensive courses. We aim to encourage outstanding young researchers to give courses at the school, in order to train them to deliver such courses. Each course will be accompanied by exercises. Evening problem sessions will be organized. Workshops will be occasions for researchers to present their results by delivering lectures, and short communications. At large conferences also poster sessions will be organized. All schools/workshops/conferences will be widely advertised, so that candidates from outside the network can also participate. If the number of places is limited, some places will be reserved to participants of the network, and some for candidates from outside (so that even a young researcher who is not employed by the network can benefit from the network's training activities, possibly by being funded from other sources). The number of schools, workshops and conferences is chosen to cover all topics while keeping the network manageable. Typically, a registered young researcher will be able to attend 2 or more events yearly.

2.2.6 Towards industry

Industrial Advisers will assist the network in furthering the existing and finding new industrial contacts. We plan to organise several day-long events as part of the workshops and conferences about industrial applications. Through these we want to encourage contact with researchers industry. At present industrial contacts include the following areas

Multifractal analysis. For example, the institute *INRIA* has a project in fractal geometry, analysing complex signals, for purposes of modelling, prediction, and synthesis, using ideas from multifractal theory, iterated function systems and fractional stable processes. The applications are divided into two parts: 1D-signals (computer network traffic analysis, financial analysis, speech synthesis) and 2D-signals (image analysis, image denoising and segmentation, image compression). Industrial connections are through the *CNET* team (fractal voice synthesis and modification, LAN traffic modelling with multifractal processes and image databases indexation using IFS characterisation), *Alcatel Escpace* (applying 2-microlocal multifractal spectra to radar image denoising) and *Alcatel ISR* (applying concepts of multifractal spectra to change detection in image sequences).

Turbulence analysis. For example, wing profiles through the engineering school of the *Orléans University,* control of the turbulence in the boundary layer of the AEDS (AIRBUS) new generation wings using feedback ionic plasma generators (through the Spanish Team), drill models and machine vibration (Lasota and Rusek at Warsaw, resulting in patents) and industrial applications through Rudnicki's group in Katowice which cooperates with AGH (Mining Metallurgy Academy in Cracow).

Porous media. The group in Bremen cooperates closely with the International Research Consortium on Continental Margins (IRCCM) which includes several industrial partners, a major part of which concerns the modelling of porous media flow in costal sediments. Similarly, associated researchers collaborate with chemists from Silesian Technical University (STU) on diffusion through porous structures.

Medical applications. Collaborations with the M. Curie Sklodowska Institute of Oncology branch Gliwice (A. Rzeszowska) in cellular population dynamics, modelling of tumors growth, their spatial structure and optimization of chemo- and radiotherapy based mathematical models. The Warsaw group also participates in the FP6 RTN "Modelling mathematical methods and computer studies of tumour

growth and therapy. Ongoing research in neuroscience where ideas from dynamics (attractors) become relevant with the emerging technology of biological information storage and retrieval as one potential application. Researchers from the German team share ideas with scientists working on data analysis for geometric objects (like finger print analysis as an industry financed project), where differential geometry seems relevant. Warwick also has a group working on systems biology (which was originally based in the mathematics department), in which dynamical systems ideas play a significant role.
Robot vision. The Swiss Team has a programme around task A1 which is related to robot vision and thus engineering, which is being developed in close collaboration with engineers.
Network problems. The Swiss team, through J.-P. Eckmann is involved in exploration of information theoretic and geometric aspects of real world networks (e.g. World Wide Web). The Finnish team has started a project with Nokia Co. on design of viable ad-hoc wireless networks, to maximize the network capacity when the number of network nodes becomes large. Here e.g. tools from information theory are used to analyze the efficiency of routing protocol quantifiers in network models.

Creation of the network and the need for training towards technological development will intensify the existing connections, influence the revival of old connections, and further development of new ones.

2.2.7 Other methods to enhance Transfer of Knowledge

1. Secondments. We shall encourage them, up to the maximal possible 30% of the time of the appointment. We shall strongly encourage short, even 1 day, visits to the seminars within the country of the site or neighbouring countries.
2. Teams will exchange information about seminars/courses and so on through their web pages, so that training and research in teams is coordinated. The teams can exchange experience, provide mutual help in overcoming difficulties etc.
3. Some lectures will be videotaped and distributed.
4. Use of a website for the RTN, with some web-based training materials.

2.2.8 Training in complementary skills

As stated above training in contact with industry/commerce is planned. ESR/ER's will be encouraged to attend courses offered by participating universities, in **communication**, awareness of **ethical issues**, enterprise and project **management skills**, foreign and local **language courses** and also in other academic subjects. Most of the participating universities offer these, frequently in English. This will also provide opportunities to meet other researchers.

2.2.9 Gender issue

This policy will include a policy for female applicants: quite a few of the key scientists in the network are women. Nuria Fagella is team leader of Spain. Viviane Baladi (France) is one of main co-authors of the project and will be invited into the Steering Committee. Others include Bodil Branner (Denmark) former vice- president of European Mathematical Society, Mary Rees (UK) ICM invited speaker. Of the Polish team, 5 out of 11 principal researchers are female. However the participation rate (about 20%) is much lower than that which we would like. Therefore special attention will be granted to female applicants, see Section 4 (by for example aiming to have females sitting on interview panels).

2.3 Impact of the training and Transfer of Knowledge programme

2.3.1 Multidisciplinarity

An important feature of this network lies in its multidisciplinary nature. Historically, most outstanding results in the field were obtained with the help of intuition, and sometimes even methods, from a priori different or even unrelated subjects.

There is no doubt that this multidisciplinary point of view requires an effort, as individual subjects have grown exponentially, and mastering more than one subject becomes more and more difficult. In addition, students arrive at graduate level with a very academic point of view, and while writing a PhD develop an expertise in a specific field and thus are totally unprepared to open their mind to other ones. This network, with its diversity of sources of expertise, is particularly well prepared to remedy this situation.

2.3.2 Need and impact of training at the European level

As remarked, the *research* in the project area is quite *fragmented in specialized topics* and research contacts between teams are far from ideal, even inside individual countries. A strong network, which is multidisciplinary yet homogeneous in terms of mathematical methods, will help to overcome these problems. By structuring the training in transverse themes (as outlined in Section 1.4), we can (i) use the full potential of available high level researchers for training purposes, (ii) cross-fertilise much more efficiently the evolving ideas in the fields and (iii) train a new generation of researchers to think in a much more multidisciplinary fashion. As mentioned, this multi-disciplinarity is crucial: holomorphic dynamics would die without knowledge in mathematical analysis background and machinery. Analysis would likewise suffer without objects existing naturally in dynamics, exhibiting universal structures which analysis can study. Feedback with physics is even more obvious. Only on a European level can this fragmentation be addressed. Of course we plan to invite experts and continue cooperation with the USA, Canada and other non-European countries. This network, led by world class experts, will attract talented young people from Europe (and elsewhere), including Russia, Ukraine and other NIS countries, much extending and reinforcing the human resources of the ERA. We expect that the Makedonian Team will also activate the region of recent turbulence. Through existing contacts, the network will also attract Chinese and other Far East young researchers and even young people from South America (there is a vivid cooperation with Brazil (IMPA Institute) and Chile). There is some excitement in Europe, especially in the associate states, that fast development is possible, which may well help to attract some of the high level scientists who emigrated to the USA to return.

The demand for researchers with these multi-disciplinary skills is enormous. The current 'large' generation of researchers who are about to retire need to be replaced by researchers who are not merely specialists in a very narrow topic, but who can see across borders. This is relevant both within academia as well as in industry (and given the *many potential industrial applications* the network will emphasize these industrial connections heavily). With the training and awareness that new researchers will be offered in the exiting and important potential applications within the field of conformal structures and dynamics, they will be much in demand.

2.3.3 Need and impact of transfer of knowledge

The network comprises one Fields medallist, one Wolf Prize medallist, four Salem Prize winners and many other outstanding experts in the field. Network wide training will allow wider impact of this

expertise, contributing to enrich Europe with a new generation of experts, capable of making advances in sciences, banking, industry, etc, that is to contribute in the Research and Technological Development.

2.3.4 Development of future careers

1) Every young pre- or post-doctoral fellow will gain genuine multidisciplinary knowledge that will be recognized later by all the universities considering hiring him/her, and help them with applying for research grants.
2) The industrial components in the training will prepare, and encourage, young researchers to contribute directly to technological development. The choice of interacting fields: from analytic tools, through fractals and dynamics, to physical processes all with industrial applications is perfect for this.
3) Due to friendships acquired in the time of participation and travelling in the network, the young researchers will become a part of new European Society.

2.4 Planned recruitment of Early Stage and Experienced Researchers

We plan to offer 252 months ESR and 168 months for ER's. This balance ER/ESR is chosen for two reasons. Firstly, within a highly technical mathematical research theme such as CODY, it is crucial that a large effort is made to enable ER's to see across research groups and research disciplines. Postdoctoral researchers are experts in their own field, who benefit most from being able to cross boundaries (and are in a better position than most ESR's to do so successfully). Secondly, many teams have existing financial support for certain number of PhD places, but postdoctoral support is much more rare.
Recruiting will be done through adverts on the CODY website, advertising on the node leader's HEI websites, through CORDIS and through network-wide search committees who also will encourage female applicants, see below.

2.4.1 168 person-months of positions for experienced researchers:

These positions will be appointments for recent post-docs, typically for half a year up to a year. In general, a one year appointment will be split into two periods/appointments to be spent at two (or more) different teams of the network (by the rules of the RTN an appointment consisting of more than 30% outside one site, needs to split in two).
Some short (1-2 weeks) visits will also be possible. This concerns both appointed researchers (secondments), and others. These shorter visits will be extremely valuable to promote interaction, but candidates must apply for such visits through a research plan in collaboration (or under supervision) of experienced mathematicians at the host-team.

2.4.2 252 person-months positions for early stage researchers:

Only a modest number of the months will be allocated to 2 or 3 year PhD positions (say, at most 4, depending on local financial needs). Also positions will be offered for early stage researchers who need special expertise from other teams to successfully complete their research. These appointments are typically for less than six months. Applicants must provide a plan for their training at the host institution. The typical appointment will be of PhD candidates who will defend their PhD within 6 months, to visit other participating institutions and who are seeking contact to start a post doctoral career and/or are looking for a post doc position, thus encouraging mobility of members of the network.

Given the appeal of working in a field with such high level senior researchers, and with the amount of training being offered, we do not expect to have any difficulties in recruiting high quality young researchers for the programme. The best young researchers can only be attracted when they are offered a post doc position (or equivalent) over a period of 4-6 years; the possibility of spending time at different teams with leading researchers makes it even more attractive. Since the network is not able to offer such career opportunities, the network institutions will provide such positions either by applying for additional research grants or through regular positions. The network will assist the team members in applications for research grants, providing the necessary scientific contacts to be able to formulate outstanding research programmes.

2.4.3 Allocation and division of responsibilities for training

	Early-stage and experienced researchers to be financed by the contract			Other professional research effort on the network project	
Network Team	ESR months (a)	ER months (b)	Total (a+b) (c)	Researchers likely to contribute (number of individuals)* (d)	Researchers likely to contribute (person-months)* (e)
1. U. Warwick	40	25	65	10-18	100
2. IMPAN	40	25	65	11-20	170
3. U.Helsinki	20	20	40	7	138
4. U. Orléans	40	30	70	19-29	170
5. U.Barcelona	20	15	35	11	138
6. U.Kiel	20	15	35	7-12	100
7. RUC/KTH	32	15	47	13-16	130
8. TEI of WM	20	8	28	7-12	130
9. U. Geneva	20	15	35	6-9	100
Totals	252	168	420	91-134	1176

* Numbers are rough estimates only. In principle, we welcome others who want to participate in the training activities. The RI percentages given in Section 3 are based on forecasted input.

During the first meeting of the network Steering Committee the details of the plans and strategy on research, training and school/workshop/conference will be finalised, and allocated to each team (according to the Tables describing the research expertise and finance allocations of the nodes, found at the end of Sections 1 and 7). The allocation will exploit the complimentary research expertises of the teams, and will be formulated in precise terms of the deliverables in terms of research and training described above. These deliverables will be robustly monitored by the Executive Committee described in Section 4.

SECTION 3: QUALITY AND INFRASTRUCTURE OF NETWORK

We outline here, according to each of the 9 partners, the specific expertise they have, justifying the hiring of young researchers and proving their ability to welcome them, and describe the local training environment, as well as the research infrastructure. The choice of partners is both based on their complementary research and training expertise and their potential (see the Table at the end of Section 1); the proposed network has the right size to be manageable while offering the advantages of scale, so all training can be delivered effectively. All partners are strong, and most (world) leading in some topics. The network will enable to exploit this, and help to create a world-class research area throughout.
Many ad-hoc collaborations and informal contacts already exist (see below), ensuring that the allocation of research training tasks as described at the end of Section 1 and 2 can be delivered efficiently.

Although the research teams are fragmented, there are already significant 'individual' contacts between many of the researchers of various teams. For example, throughout the range of analysis, geometry and dynamics, French and Finnish team members collaborate. Within mathematical physics members from teams [4], [9] and [1] have joint projects. There are collaborations in multifractal theory between members of teams [1], [4], [8]. Also there were previous successful exchanges of graduate students (holding various kinds of grants including Marie Curie individual fellowships) between U. Barcelona, DTU, U. Jyväskylä, U. Warwick, IMPA: most grantees have now become established mathematicians.

PARTNER 1 – WARWICK/UK (LEADER SEBASTIAN VAN STRIEN)

Warwick's Mathematics Institute is one of the UK's highest rated departments having achieved the highest (5*) rating in applied maths in the 2001 Research Assessment Exercise. The department recently moved to a new building with state-of-the-art facilities. In recent years it has won several major research grants and fellowships, has coordinated the PRODYN network funded by ESF and the LOCNET RTN funded by the EU, run three Marie Curie early stage training sites under FP5 and hosted several MC fellows. Currently Warwick has about 35 postdoctoral fellows, and 60 PhD's.

The Dynamics Group is one of the strongest in the department, and has hosted numerous conferences, including a recent one-year symposium attended by well over 500 participants, including many leading researchers. The Group has specific expertise in interval and holomorphic dynamics, quasiconformal mappings and Teichmuller theory. Also there are strong activities in ergodic theory, Kleinian groups, applied dynamical systems and Hamilton dynamics. The Group has extensive links with many others in the UK and the rest of the world (in particular Europe, USA, Canada, Brazil, China).

***Principal researchers for this project*:**
Sebastian van Strien (Professor: **Team and Network Coordinator**): Managing editor Ergodic Theory and Dynamical System. Coordinated conferences, ESF and Marie Curie programs. Expert in Real and complex one-dimensional systems, low-dimensional dynamics and bifurcation theory. (50%)
Oleg Kozlovski (Lecturer). Expert in real/complex one-dimensional systems and dynamo theory. (20%)
Adam Epstein (Lecturer). Expert in Complex Analytic dynamics, Riemann Surfaces, Value-distribution theory. (30%)
Anthony Manning (Reader). Expert in complex and symbolic dynamics, Hausdorff dimension, geodesic flows. (10%)

Robert MacKay (Professor). Major contributions in Hamiltonian dynamics, complex maps lattices and spatial structures. (10%)
Vladimir Markovic (Reader). Major contributions in Geometric analysis, Teichmüller theory, quasiconformal harmonic maps, Kleinian groups. (30%)
Mark Pollicott (Professor) Expert on ergodic theory, topological/smooth dynamics. (15%)
Caroline Series (Professor) Expert on Fuchsian and Kleinian groups. (15%)

Associated researchers:
I. Stewart (Warwick); *S. Kuksin* (Edinburgh); *S. Bullet Ch. Beck, O. Jenkinson, Ch. Penrose, M. Freiberger* (QMW); *H. Bruin, M. Holland,* (Surrey); *J. Cardy* (Oxford); *J. Lamb*, *S. Luzzatto* (Imperial); *L Rempe, M. Rees* (Liverpool); *P. Rippon, G. Stallard* (Open University); *K. Falconer, B. Stratmann,* (St. Andrews); *S. Velani:* (York).

***Selected Publications*:**
H. Bruin, W. Shen , S. van Strien, *Invariant measures exist without a growth condition*, Commun. Math. Phys. 241 (2003), 287-306.
O. Kozlovski, W. Shen and S. van Strien, *Density of hyperbolicity in dimension one*. To appear in Ann. Of Math.
V. Markovic, *Quasiconformal homeomorphisms and the convex hull boundary*. Ann. of Math 159 (2004), no 1, 305-336.

PARTNER 2 – IMPAN/POLAND (LEADER FELIKS PRZYTYCKI)

The Institute of Mathematics of Polish Academy of Sciences (IMPAN) and its conference/training branch: Stefan Banach International Mathematical Center (BC), employs about 40 researchers on full time permanent or long period positions and other about 40 on 1 year (mostly postdoc) or part time positions. It leads PhD studies with 22 PhD students now. It closely cooperates with Universities (Warsaw, Wroclaw, Poznan, Torun, Gdansk, Katowice, Krakow, Lodz, etc.); it has small branches in some of these cities. It is editing several international math. journals and serials: Acta Arithmetica, Annales Pol. Math., Applicationes Math., Banach Center Publ., Colloquium Math., Dissertationes Math., Fundamenta Mathematicae, Studia Mathematica. Its library is one of best math. libraries in the world. IMPAN-BC hosted a Center of Excellence and Marie Curie Training Site within FP5. Now it hosts two FP6 ToK's programmes; it is a node to ECRYPT NoE and the MC training network 'phenomena in high dimensions'. The Banach Center, directed by an international scientific committee, organizes about yearly 30 international conferences and schools in Warsaw and new IMPAN conference/research centre in Bedlewo (near Poznan) having about 120 accomodation places. In Warsaw IMPAN building there are around 20 hotel rooms for visitors.

Warsaw has a long-standing tradition in Quasiconformal Mappings and Dynamical Systems. In particular the team will concentrate on holomorphic dynamics, and on analysis on metric spaces and connections between quasiconformal mappings and calculus of variations. Bojarski was among the pioneers of the analytic theory of quasiconformal mappings in two and more dimensions and the famous Measurable Riemann Mapping Theorem. Iwaniec, Hajlasz (both now in the USA) and Strzelecki, Kalamajska and Zatorska in the team, are his children and grandchildren. Dynamical systems started in 60s (influenced by Ja.Sinai), with Krzyzewski and Szlenk and later with Misiurewicz as pioneers. Around 1983 holomorphic iterations were started by Przytycki, Kotus, Urbanski and Zdunik which resulted in a theory comparing harmonic to Hausdorff and Gibbs equilibrium measures, influenced by L. Carleson (KTH), and iteration of meromorphic maps. Some other topics of activity of the group include conformal and invariant measures on Julia and radial Julia set for entire and meromorphic functions, iteration of holomorphic Collet-Eckmann maps, statistics of returns in

dynamics, entropy, non-conformal IFS, relations with differential geometry and mechanics, etc. The team organized holomorphic iterations workshops in 1995 (within a larger programme) 1998, 1999, 2002 and 2005 in the Banach Center in Warsaw.

Principal researchers for this project:
Krzysztof Baranski, assistant professor. Iteration of transcendental functions, dimensions of graphs of lacunary Fourier series. Multifractals. (50%)
Bogdan Bojarski, full professor, member of the Polish Academy of Sciences. Pioneer in Quasiconformal Mappings Theory. (20%)
Agnieszka Kalamajska, assistant professor. PDE's and variational problems. (20%)
Boguslawa Karpinska, assistant professor. Iteration of entire and meromorphic maps. (30%)
Janina Kotus, professor. One of pioneers of iterations of meromorphic functions. (30%)
Feliks Przytycki **(Team Coordinator)**, full professor. Applications of ergodic theory and thermodynamical formalism to holomorphic dynamics; boundary growth of analytic functions. (30%)
Michal Rams, assistant professor. IFS with overlaps, dimensions of solenoids, packings. (40%)
Pawel Strzelecki, associate professor. Expert in PDE and variational problems. (20%)
Maciej Wojtkowski, full professor. ICM 2002, Expert in hyperbolic dynamics, billiards, geodesic flows .(20%)
Anna Zatorska-Goldstein, PDE's and variational problems. (30%)
Anna Zdunik, associate professor. Expert in harmonic measure and equilibria in holomorphic dynamics, statistics of returns, meromorphic dynamics. (30%)

Associated researchers: A. Lasota, R. Rudnicki, J.Jaroszewska, T. Szarek (Silesian University and IMPAN, Lab. of Biomathematics); H. Zoladek, J. Miekisz, G. Lukaszewicz (Warsaw); M. Lemanczyk, K. Fraczek (Torun); G. Swiatek (Penn State and Warsaw); T. Downarowicz (Wroclaw), T. Iwaniec (Syracuse, NY, and Warsaw); M. Urbanski (North Texas and Warsaw); G. Levin (Jerusalem), K. Simon (Budapest); J. Rivera-Letelier (Antofagasta); B. Skorulski (Antofagasta and Warsaw).

Selected publications:
F. Przytycki, J.Rivera-Letelier, S.Smirnov, *Equivalence and topological invariance of conditions for non-uniform hyperbolicity in the iteration of rational maps*, Inventiones Math. 151, (2003), 29-63.
P. Strzelecki, A. Zatorska-Goldstein, *A compactness theorem for weak solutions of higher-dimensional H-systems*, Duke Mathematical Journal 121(2) (2004), 269-284.
M. Urbanski, A. Zdunik, *Hausdorff dimension of harmonic measure for self-conformal sets*, Advances in Math. 171 (2002), 1-58.

PARTNER 3 – HELSINKI/FINLAND (LEADER KARI ASTALA)

In Finland, Helsinki Mathematics department is the leading center of mathematical research. Currently the department participates in several Centers of Excellence nominated by the Academy of Finland, with two of them coordinated from Helsinki. The department occupies a new modern building, offering all modern technological facilities.

Finland has particularly strong traditions in geometric analysis based on conformal and quasiconformal methods, and the Finnish team collects the leading experts in the country, from the universities of Helsinki (HU) and Jyväskylä (JU). In addition the team is joined by groups from geometric measure theory and mathematical physics, where in both the senior members are international leading experts in their fields. The teams have regularly organized conferences and

different training activities, with the annual international Jyväskylä summer school offering a regular basis for further training in the topics of this proposal.

***Principal researchers for this project**:*
Kari Astala (HU, Academy Professor; **Team Coordinator**): Salem Prize 1994, Expert in quasiconformal mappings and their applications. Used dynamical methods to prove the fundamental Gehring-Reich conjecture on qc-mappings. Organized several conferences and summerschools, President of the Finnish mathematical Society. (50%)
Antti Kupiainen. (Academy Professor) Expert in mathematical physics, has pioneered the renormalization group in rigorous quantum field theory, random systems, PDE's and dynamics. Introduced anomalous scaling in turbulent systems; proved the ergodicity of the two-dimensional stochastic Navier-Stokes dynamics. (30%)
*Pertti Mattila (*Professor) Expert in geometric measure theory, rectifiablity and multifractal phenomena. Introduced new novel methods in removable singularities of bounded holomorphic functions. Leader of Finnish CoE in geometric analysis. (30%)
Ilkka Holopainen (lecturer) Expert in quasiconformal mappings and analysis in metric spaces (20%)
Pekka Koskela (JU, Professor) Expert in mappings of finite and bounded distortion, analysis in metric spaces. Established the quasiconformal theory of metric measure spaces and foundations of modern theory of mappings of finite distortion in space (30%)
Esa Järvenpää (JU, Professor). Expert in geometric measure theory and extended dynamical systems (20%)
Maarit Järvenpää (JU, Lecturer) Expert in geomteric measure theory (20%)
Kaj Rajala (JU, Academy researcher). Expert in quasiconformal and quasiregular mappings in space (50%)

Selected publications:
J. Bricmont, A. Kupiainen and A. Schenkel, *Renormalization group and the Melnikov problem for PDE's*. Comm. Math. Phys. 221 (2001), no. 1, 101—140.
D. Faraco, P. Koskela, Pekka, X. Zhong, *Mappings of finite distortion: the degree of regularity*. Adv. Math. 190 (2005), no. 2, 300--318.
Mattila, Pertti, *Hausdorff dimension, projections, and the Fourier transform*. Publ. Mat. 48 (2004), no. 1, 3--48.

PARTNER 4 – ORLÉANS/FRANCE (TEAM LEADER: MICHEL ZINSMEISTER)

The Orleans team is part of the laboratory "MAPMO" (UMR 6628) which has recently merged with the mathematics laboratory of the University of Tours to form the "Fédération Denis Poisson", one of the biggest CNRS-associated mathematical laboratory in France. This laboratory has a strong group in dynamical systems, with a large spectrum of themes: ergodic theory and geometry, fractal and multifractal analysis, holomorphic dynamics and mathematical physics. It has about 40 PhD students and hosts many postdocs (including from different EEC RTN contracts). This team was one of the leading teams of HCM contract ERB CHRX CT92 0071, and has a long tradition of organisation of conferences, summer schools and all kind of events. The geographical central position of Orleans allows moreover to optimise its interaction with the other participants of the team who are spread around France (*Paris, Marseille, Toulouse, Rennes, Lille, Clermont Ferrant*). All these centres have a long tradition of cooperation through different existing French or European networks such as:

- Grefi-Mefi, a Franco-Italian research group (GDR).

- Polynomial Dynamics, an ACI (network of young researchers) run by Serge Cantat (Rennes) and involving Marseille, Toulouse and Paris 6.
- GDR Theorie ergodique et systemes dynamiques involving all the quoted centers.

Principal researchers for this project:

Michel Zinsmeister: Professor (Université d'Orléans). **Team coordinator**. Expert in Geometric Function Theory, especially Hausdorff dimension of Julia sets, thermodynamic formalism. (50%)

Viviane Baladi: Researcher. Institut de Mathematique de Jussieu, Université Paris 7. Invited speaker at ECM, Barcelona 2000. In editorial boards of Ann. Sc. ENS, ETDS, Ann IHP physic theor. Expert in dynamical zeta functions and dynamical spectrum: spectrum of the transfer operator in non uniformly hyperbolic settings, small random perturbations, extension of the Milnor-Thurston kneading theory in higher dimensions; SRB measures and spectrum of coupled map lattices, anisotropic spaces of distributions and dynamics". (20%)

Artur Avila: Researcher, Dynamical systems, Statistical properties of unimodal maps, ergodic properties of interval exchange maps and Teichmueller flows, spectrum of Schroedinger operator. (15%)

Jérôme Buzzi: Researcher (École Polytechnique).Studies of various complexities and their interplay with dynamical properties such as semi-uniform hyperbolicity - the study of complexity itself (through measures with maximum entropy --- e.g. for entropy-expanding maps) as well as classical issues like absolutely continuous invariant measures and thermodynamic formalism . (15%)

Guy David: Professor (Université Paris-Sud, Orsay). Invited speaker at ICM, Berkeley 1986, Salem prize 1987, IBM-France prize 1990. His work with S. Semmes (invited speaker at ICM, Zürich 1994) has received international recognition. Expert in harmonic analysis, singular integral operators; geometric measure theory: uniformly rectifiable sets; image processing: minimizers of Mumford-Shah functional. (5%)

Volker Mayer: (Maître de Conférences, Université de Lille 1) Quasiconformal Analysis, Iteration of meromorphic functions. (15%)

Bertrand Duplantier: Researcher (CEA – Saclay). Expert in Conformal Field Theory and more specially in scaling limits of various discrete models of statistical mechanics where he has major contributions. (20%)

Jacek Graczyk: Professor (Université Paris-Sud, Orsay). Expert on geometric and measure theoretic aspects of non hyperbolic dynamical systems in real or complex dimension 1. (10%)

Pierre Pansu: Professor (Université Paris-Sud, Orsay). Expert in Riemannian geometry: isoperimetric inequalities; analysis on Carnot groups; geometric group theory: rigidity of symmetric spaces. (20%)

Jean-Christophe Yoccoz (Collège de France). Salem Prize 1988, Fields medalist 1994. Expert in non uniformly hyperbolic dynamics; one-dimensional dynamics over the reals, complex and p-adic numbers; KAM theory, small divisors; recent interests include lemmings population models. (10%)

Tan Lei: Maître de Conférences (Université de Cergy-Pontoise). Expert in iterations of rational maps, more particularly: the topology and geometry of the the unstable phases (the Julia set), their counterpart in the parameter space, and realisations of systems with given combinatorics. (20%).

Claude Tricot: Professor (Université de Clermont-Ferrant). Expert in multifractal analysis and Dimension Theory. (20%)

Anton Zorich: Professor (Université de Rennes 1). ICM talk 2006. Expert in geometry and topology of the moduli spaces of quadratic differentials, in Teichmuller geodesic flow, in geometry and dynamics of translation surfaces and of measured foliations. (10%)

Vincent Beffara (Researcher, CNRS UMR 5669 at ENS-Lyon), expert on random walks and SLE. (15%)

Xavier Buff (Université Paul Sabatier, Toulouse). Maître de Conférences. Holomorphic dynamics: boundaries of Siegel discs, renormalization. (20%)
Arnaud Chéritat (Université Paul Sabatier, Toulouse). Maître de Conférences. Holomorphic dynamics: boundaries of Siegel discs, renormalization. (20%)
Sébastien Ferenczi: researcher, CNRS, Institut de Mathématiques de Luminy, Marseille. Expert on interactions between dynamical systems, arithmetic, and word combinatorics. (30%)
*Julien Barral***:** researcher, INRIA, expert in fractal and multifractal analysis, multiplicative cascades. (10%).
Bernard Sapoval: Directeur de recherché*, CNRS,* Ecole Polytechnique, Laboratoire de Physique de la Matière Condensé. Expert on physics of fractals and irregular systems. Extensive industrial collaborations with COLAS SA (sound waves on roads) and others. (15%)

***Associate researchers*:** A.Batakis, S.Cantat, M. Bauer, D. Bernard, M. Bourdon, A. Douady, M. Peigne, P. Flajolet, H-H. Rugh, Y. Heurteaux, R. Perez- Marco, P. Arnoux, X. Bressaud, P. Haissinsky, J. Hubbard, P. Hubert, S. Vaienti, K. Gawedski, M. Peigne, S.Tcheremchantsev, S. Crovisier.

Selected Publications:
B.Duplantier: *Conformal Fractal Geometry and Boundary Quantum Gravity*. Proceedings of Symposia in Pure Mathematics, 72-2, 2004.
X.Buff, A.Chéritat : *Ensembles de Julia quadratiques de mesure strictement positive*. CRAS Paris, 341, décembre 2005.
A.Avila, C. G. Moreira : *Statistical properties of unimodal maps: physical measures, periodic points and pathological laminations*. Publications Mathématiques de l'IHÉS 101 (2005), 1-67.

PARTNER 5 – BARCELONA/SPAIN (LEADER NURIA FAGELLA)

The Spanish team is based at University de Barcelona (UB), and is formed by members from several research groups in the area, all of them with long term expertise in research and training activities. In recent years, these groups obtained several major research grants and have run two Marie Curie early stage training sites, hosting several MC fellows from different European countries. The team has plenty of experience hosting and organizing international conferences (PhD-Euroconferenc CAD2000, ``Discrete dynamics" 1999, joined AMS-RMSE meeting (2003), yearly DANCE winter schools, etc). The team's specific expertise is in low dimensional topological dynamics, holomorphic dynamics in one variable and the transition to several complex variables. There is also a very strong activity in Hamiltonian dynamics, KAM theory and planar vector fields. The team members have research links with plenty of research groups across Europe and the US (in particular with teams 1,2,4,6 and 7).

***Principal researchers for this project*:**
Nuria Fagella (Associated Professor, UB: **Team Coordinator**). Main organizer of several international meetings and training schools. Expert in one dimensional holomorphic dynamics, with emphasis in quasiconformal surgery, entire transcendental maps and complexification of circle maps. (50%)
Lluis Alseda: (Full professor, UAB). Expert in low dimensional topological dynamics with contributions to holomorphic dynamics. (35%)
F. Mañosas (Associate proff. UAB). Expert in low dim. topological dynamics (30%)
Xavier Jarque: (Associate Professor, UB). Expert in complex dynamical systems (with emphasis in entire transcendental maps) and planar vector fields. (30%)
Joan Carles Tatjer (Associate Professor UB). Expert in homoclinic phenomena in low dimensional dissipative maps, and quasi-peridically forced systems. (20%)

Jordi Villanueva (Associate Professor, UPC) Expert in KAM theory for Hamiltonian systems and symplectic maps and applications to physics. (20%)
Teresa Martinez-Seara (Associate Professor, UPC). Expert in asymptotic calculations of exponentially small phenomena and its relation with Ecalle resurgence theory. (20%)
Xavier Massaneda (Associate Professor UB) Expert in several aspects of function theory in one and several complex variables. (20%)
*Joaquim Ortega-Cerda (*Associate Professor UB) Expert in several aspects of function theory in one and several complex variables (20%).
Antonio Garijo (Associate Professor URV) Expert in holomorphic dynamics and polynomial vector fields. (30%)
David Juher (Lecturer UdG) Expert in low dimensional topological dynamics. (30%)

Selected Publications:

N.Fagella, C.Henriksen, Deformation of entire functions with Baker domains, To appear in *Discrete and continuous dynamical systems (A).*
A.Garijo, A.Gasull and X.Jarque, On the period function of a family of complex differential equations. To appear in *J.Differential Equations.*
Ll.Alseda, F.Gautero, J.Guaschi, J.Los, F.Manosas and P.Mumbru, Patterns and minimal dynamics for graph maps, *Proc.London Math. Soc*. (3), **91** (2005), 414-442.

PARTNER 6 – KIEL/GERMANY (LEADER WALTER BERGWEILER)

The three participating institutes in Kiel (organisation), Bremen and Göttingen are top ranked mathematics research and education centres in northern Germany (e.g. the latest research evaluation of the state of Lower Saxony in 2003). They offer modern working facilities for young researchers (PhD- and Postdoc-programmes). Well-trained personnel and up-to-date conference sites are available to host major international conferences and workshops. In recent years the institutes have received several larger research grants and special DAAD funding for PhD-programmes, and also participated in European-wide funded networks (PRODYN, RTN-networks, MC fellows). Currently, some 90 PhD students are enrolled into the PhD programmes at these institutions, hosting as well 40 postdoctoral researchers. The team's expertise encompasses many areas of dynamics and beyond: conformal dynamics, maps of the interval, probabilistic methods in dynamics, Kleinian groups, fractal geometry, ergodic theory. Team members have won scientific prizes and organised several prestigious research projects (among them three PhD-Graduate Schools (GAUSS), two larger research cooperations and special research semesters (ESI)) and numerous international conferences (up to 200 participants). The group has extensive links to the main research centres in dynamics around the world through joint research projects.

***Principal researchers for this project*:**

Walter Bergweiler (Professor, Kiel University; **Team Coordinator**): Co-Editor, *Comp. Meth. Funct. Thy*, *J. Analysis*, *Complex Variables*. Expert in holomorphic dynamics (especially transcendental dynamics), Nevanlinna theory, normal families. (40%)
Manfred Denker (Professor, Göttingen University): Chief editor, *Stochastics and dynamics*. Leading researcher and administrator of 3 graduate schools and 1 research institution. Former dean of faculty and department chairman. Expert in ergodic theory, dynamical systems, probability theory and statistics. (20%)
Vadim Kaimanovich (Professor, International University Bremen): Organizer of special semesters at the Schrödinger Institute Vienna (ESI) in Vienna (2001 and 2007). Expert in probability, geometry and

dynamics, especially random walks and Brownian motions, ergodic theory, combinatorial and geometric group theory, foliations. (20%)
Samuel J. Patterson (Professor, Göttingen University): Leading researcher of a graduate school. Former editor of *J. Reine Angew. Mathematik*, head of the Sonderforschungsbereich 170 and Dean of Faculty and chairman of Mathematics Institute. Expert in analytic number theory, Kleinian groups, Teichmüller theory, hyperbolic geometry. (10%)
Dierk Schleicher (Professor, International University Bremen): Responsible for building up the mathematics department at IUB, local organizing chairman, International Mathematics Olympiad 2009. Expert in conformal dynamics (especially symbolic and transcendental dynamics, and parameter spaces), and hyperbolic and fractal geometry. (20%)
Associated researchers:
G. Keller (Erlangen); *M. Keßeböhmer* (Univ Bremen); *Susanne Koch* (Göttingen); *M. Oliver, P. Schupp* (IU Bremen).

Selected Publications:
Bergweiler, Walter: *On the number of critical points in parabolic basins*. Ergodic Theory Dynam. Systems 22, 655-669 (2002).
Denker, Manfred: *Einführung in die Analysis dynamischer Systeme*. Springer-Verlag 2005.
John Hubbard, Dierk Schleicher, Scott Sutherland: *How to find all roots of complex polynomials by Newton's method*. Inventiones Mathematicae 146 (2001), 1-33.
Vadim. A. Kaimanovich, Mikhail Lyubich: *Conformal and harmonic measures on laminations associated with rational maps*, Mem. Amer. Math. Soc. 173 (2005).

PARTNER 7 – RUC DENMARK/SWEDEN (LEADER CARSTEN LUNDE PETERSEN)

The Danish part of this team covers the greater Copenhagen area. It is directed from Roskilde University and includes the Technical University of Denmark and Copenhagen University. The team is hosting yearly combined thematic workshops and ph. Courses in holomorphic dynamics. The group has leading expertise in holomorphic dynamics, quasi- and transquasi conformal surgery. The group has extensive links with many other groups in Europe and the US.
The Swedish part of this team is mainly located at the Royal Institute of Technology (KTH), Stockholm. The team is centred around the dynamics and analysis group of KTH, through which the proposed Network will also gain access to other analysis groups at KTH, Stockholm University, Lund University (LU/LTH), and elsewhere in Sweden. KTH has a long tradition of research in many areas of analysis, dynamical systems, and mathematical physics, with many important results established by the group. In the last few years, the members of the group worked on most of the areas of the proposed network.

The KTH team successfully administered several networks and collaboration agreements, in particular with IMPA (Brazil), Steklov Institute (Russia). At present KTH administers the Swedish-North American Analysis network, which is in its fourth year and includes Caltech, Princeton, Yale, and University of Toronto. KTH team organized a number of highly successful conferences and programs at KTH and the Mittag-Leffler Institute, including schools for graduate students. KTH hosted the European Congress of Mathematics in 2004.

***Principal researchers for this project*:**
Carsten Lunde Petersen (assoc. prof.: **Team Coordinator**, RUC): Has organized conferences and workshops. One-dimensional holomorphic dynamical systems, trans-quasi conformal surgery. (25%)
Bodil Branner (assoc. prof., DTU). Has organized a large Nato ASI- Summer school and served scientific committees at all levels. Expert in One-dimensional holomorphic dynamical systems. (10%)
Christian Henriksen (assoc. prof., DTU). Expert in One-dimensional holomorphic dynamical systems. (15%)
Alexandru Aleman: Associate professor LU, MNF, expert in operator theory (50%)
Michael Benedicks: Full professor, KTH. Expert in stochastic behaviour of dynamical systems, in particular Hénon attractors, ergodic theory and SRB-measures, random perturbations of dynamical systems, harmonic analysis. Organizer of the conference "Perspectives in Analysis" (KTH, 2003). Former president of the Swedish Mathematical Society, Eklundska priset of the Royal Swedish Academy of Sciences, ICMP invited speaker 1988, ICM invited speaker 2002. (25%)
Lennart Carleson: Professor emeritus, KTH. Fundamental contributions to many areas of classical analysis, dynamical systems, and mathematical physics relevant to the project, including the theory of extending quasiconformal mappings in higher dimensions, univalent functions, Hénon attractors, geometry of Julia sets and more recently percolation and DLA. Member of the Royal Swedish Academy of Sciences and corresponding member of other academies. Wolf prize 1992, Leroy P. Steele Prize 1984, ICM invited speaker 1962, 1966, 1990. Former president of the International Mathematical Union. (20%)
Haakan Hedenmalm: Professor, KTH. Expert on Bergman spaces, reproducing kernels, invariant subspaces, conformal mapping. Wallenberg prize 1992, Benzelius prize 1995, G Gustafsson prize 2000. ECM invited speaker 1996. (15%)
Kurt Johansson: Professor, KTH. Expert in mathematical statistical mechanics, random matrices, distribution of the longest increasing subsequences, with relations to the Tracy-Widom distribution. Wallenberg prize 1995; Rollo Davidson Prize 2000; Gustafsson prize 2002; ICM invited speaker 2002. (15%)
Mattias Jonsson: Associate professor, KTH. Expert in dynamics in several complex variables, polynomial endomorphisms of Ck, holomorphic motions. (15%)
Mario Natiello: Associate professor, LU. Expert in applied dynamical systems (especially bifurcation theory) and approximations to stochastic processes. Organizer of "Dynamical systems and number theory" workshop, 2002, LU. (10%)
Joerg Schmeling: Full professor, LU. Expert in smooth ergodic theory, dimension theory, multifractal analysis, 1996 Leopoldina Research Award. Organizer of "Dynamical systems and number theory" workshop, 2002, LU. (20%)
Serguei Shimorin: Associate professor, KTH. Expert in Hilbert spaces of analytic functions with applications of operator theory methods; applications of holomorphic spaces and operator theory methods to conformal mappings. St. Petersburg Math. Society Prize 1994. (15%)
Hans Thunberg: Associate professor, KTH. Expert in one-dimensional dynamics and applications of dynamics to biology. (20%)

Associated researchers:
S. Eilers (assoc. prof. KU), *J. Ottesen (RUC*), *P. G. Hjorth,* (assoc. prof DTU)

Selected Publications:
C. Petersen, S. Zakeri, *On the Julia set of a typical quadratic polynomial with a Siegel disk*, Ann. of Math. **159** (2004) 1-52.
X. Buff, N. Fagella, L. Geyer and Ch. Henriksen, *Arnold Disks and Herman Rings*. To appear in Journal of the London Mathematical Society.

Dynamics on the Riemann Sphere, Editors Poul G.Hjorth and Carsten Lunde Petersen, EMS Publishing House, 2006.
L Carleson, N. Makarov, *Aggregation in the plane and Loewner's equation*, Comm. Math. Phys. 216 (2001), no. 3, 583-607.

PARTNER 8 – TIWM/GREECE (ANTONIOS BISBAS)

Technological Institution of West Macedonia is one of the highest education institutes of Greece. The Institution is located in a modern building and is equipped with high technology laboratories. The Department of General Sciences coordinates with numerous other Technological Institutions and Universities and runs a large amount of projects funded by EU.

The Mathematics group is one of the strongest in the department, and its members include a large number of Professors and post doctoral fellows, covering a wide range of topics such as Harmonic and wavelet Analysis, Approximation Theory, Dynamical systems, measure theory, fractal Analysis. Also there are strong activities in Probability theory, Complex Analysis and Algebra. The group has extensive links with many others in Europe and USA.

Principal researchers of the project:

Bisbas Antonios (Professor: Team Coordinator): Participated in a lot of conferences, coordinator some projects. Expert in Fractal - Multifractal Analysis and Harmonic Analysis. (50%)
Christoforos Mouratidis: (Visiting Ass. Prof.) Contributions in Complex Analysis. (20%)
Ioannis Kipouridis: (Visiting Ass. Prof.) Contributions in Probability theory, Matrix Analysis. (10%)
Nikolaos Atreas: (Visiting Ass. Prof.) Contributions in Approximation Theory, Sampling Theory with Wavelets. (30%)
Costas Karanikas: (Professor in CSD of Thessaloniki) Expert in Harmonic Analysis, Measure Theory, Wavelet Analysis. (10%)
Ioannis Antoniou: (Professor: in Department of Mathematics of Thessaloniki) Expert in Chaotic and complicated systems. (10%)
Gatzouras Dimitrios: (Assistant Prof., General Sciences Department, Agricultural Univ.of Athens) Harmonic Analysis, Fractals. (10%)

Accosiated researchers:

A. Michalis, *P. George* (Aegean Univ.), *C. Charalampos, P. Ioannis* (Agricultural University of Athens), *P. Leonidas:* (TEI of West Macedonia).

Selected publications:

A. Bisbas, *Normal numbers from infinite convolution measures*, Ergodic Theory and Dynamical Systems, 23, 3, (2003), 389-393.
D. Gatzouras, S. Lalley**,** *Statistically Self-Affine Sets: Hausdorff and Box Dimensions*, Journal of Theor. Prob., 7 (1994), 437--468.

PARTNER 9 – GENEVA/SWITZERLAND (LEADER STANISLAV SMIRNOV)

The main centres for network activities in Switzerland will be Geneva and Bern. Participation of research groups in Lausanne, Fribourg, Neuchatel is also planned. There is a long tradition of networking and cooperation between these closely situated universities.
The Geneva group is located at the mathematics and physics departments, with interests in mathematical physics and analysis, including dynamical systems, stochastic and fractal geometry,

complex analysis. The group in Bern is at the departments of mathematics and statistics, with research focused on geometric analysis, including quasiconformal mappings, Lie groups, stochastic and fractal geometry. Collaborators in Lausanne, Fribourg, Neuchatel work on conformal geometry, geometric analysis, Kleinian groups. The Swiss team regularly collaborates with physicists working in related areas.

Cooperation in research and training between Swiss universities includes joint graduate courses, regular schools and workshops. A research network on geometric analysis has recently been established between the University of Bern, ETH Zurich and EPF Lausanne, it has a topical overlap with the current proposal so we expect a fruitful collaboration between the two networks. Universities in Geneva, Fribourg, Neuchatel and EPF Lausanne jointly run training activities for graduate students and young researchers within the framework of the "Troisième cycle romand de mathématiques". This includes an annual winter school in Les Diablerets, in 2005 and 2006 organized by team members on network-related topics. We plan to prepare one of the next schools with a large participation of other network teams, specifically inviting many graduate students. Members of the Swiss team also organize annually Borel seminar: a one-semester topical event starting with basic expositions and ending with invited talks by international experts, and we plan to devote one to the network-covered topic, attracting researchers from other teams. Swiss team actively participates in international collaboration, including training of young researchers (much of it funded by the Swiss NSF, ca. 500'000SFr/year). Participants have previous experiences in managing large international Networks. The Swiss team has well developed connections with the French and Finnish teams and interacts with most other teams of the network.

The Swiss team has extensive experience in organising conferences and training graduate students. Because of its convenient central location in Europe and team's infrastructure, Switzerland will be a perfect location to host network-related conferences and schools.

***Principal researchers for this project*:**
Stanislav Smirnov (Full professor, University of Geneva, **Team Coordinator**). Expert in complex analysis and dynamics, mathematical physics. Organized conferences and coordinated research programs. Coordinator of large North American-Swedish network funded by STINT, 2002-2006. Editor of International Math Research Notices. St.-Petersburg Math. Society Prize 1997, Salem Prize 2001, Clay Research Award 2001, Gustafsson Research Prize 2001, Rollo Davidson Prize 2002, ICMP plenary speaker 2003, EMS Prize 2004, ECM speaker 2004, ICM speaker 2006. (50%)
Jean-Pierre Eckmann (Full professor of Physics and Mathematics, University of Geneva). Expert in dynamical systems, stochastic partial differential equations, geometry of real-world networks. ICM speaker, 2002. Vice-president, Physics Institute, Geneva. Member, Göttingen Academy. (30%)
Zoltan Balogh (Full professor, University of Bern). Expert in geometric analysis, quasiconformal mappings, several complex variables, complex dynamics. Co-organizer of the Borel Seminar on Complex Dynamics, (1996), Analysis Workshop in Bern (2001), Borel Seminar on Tangent spaces of metric spaces (2003). (15%)
Frank Kutzschebauch (Full professor, University of Bern). Expert in several complex variables, group actions on complex manifolds. Organizer of the International Conference in Several Complex Variables (Sundsvall 2004). (10%)
Ilya Molchanov (Full professor, University of Bern). Expert in stochastic geometry, random fractals, limit theorems, point processes. Organizer of Conference in Stochastic Geometry and Applications (Bern 2005). (10%)

Hans-Martin Reimann (Full professor, University of Bern). Expert in analysis on Lie groups, quasiconformal mappings, harmonic analysis, wavelets. Organizer of the Analysis Colloquium (satellite conference to ICM Zurich) in 1994. Co-organizer of the Borel Seminar on Complex Dynamics, (1996), Borel Seminar on wavelets (1998), Analysis Workshop in Bern (2001), Borel Seminar on Tangent spaces of metric spaces (2003). (10%)

Associated researchers:

B. Colbois (University of Neuchatel), R. Kellerhals (University of Fribourg), M. Troyanov (EPF-Lausanne)

Selected Publications:

Z. Balogh and S.M. Buckley, *Geometric charaterizations of Gromov hyperbolicity.* Inventiones Math. 153 (2003), 261-301.

J.-P. Eckmann, E. Moses*, Curvature of co-links uncovers hidden thematic layers in the world-wide web,* Proceedings of the National Academy of Science (USA), 99 (2002), 5825-5829.

S. Smirnov, *Critical percolation in the plane:conformal invariance, Cardy's formula, scaling limits,* C. R. Acad. Sci. Paris Sér. I Math., 333 (2001).

Relationship within teams

The scientific institutions in which the team leaders are based will be the contractual partners of the network. To these institutions funds will be distributed as described in Section 6; these institutions will be responsible for contractual obligations, audits and so on. However, if it turns out more appropriate that, say, an ER or ESR is employed by another institution associated to a team, the money will be reallocated accordingly. The network will aim to be inclusive and outwards looking, creating a framework for young and senior researchers who are not listed above to share the benefits from this network.

SECTION 4 - MANAGEMENT AND FEASIBILITY

4.1. Proposed management and organisational structure

The network management structure will be divided into network-wide and local levels. The overall responsibility for the management rests with the network coordinator (CO), Sebastian van Strien from the Mathematics Institute at the University of Warwick, UK. He will chair a Steering Committee (StC) which includes the team leaders, together with 3-5 other leading scientists from the network. At the local level, each team leader will be joined by 2-4 members who form the local steering committee.

4.1.1 The Network Coordinator (CO) and Network Office

The network will be coordinated by Prof. Sebastian van Strien, who has wide experience managing European Community, ESF and EPSRC programs, see Sections 3 and 4.3.2. He is responsible for all management tasks according to the RTN rules, and responsible for the cooperation with the European Commission. He is responsible for the scientific orientation and quality of the network and supervises training activities. He stays in continuous contact with the members of the Steering Committee. He calls meetings of the Steering Committee and chairs them. He is assisted by the Network Administrator, who will be appointed for 1 day per week and whose duties include:

- Running the network office and liaise with the accountant offices.
- To coordinate and initiate contact between teams.
- To facilitate training, recruitment, and advertisement of the programme.
- To initiate the monitoring procedures which are put in place, see Section 4.2.
- To create and maintain a webpage to distribute information and support the communication between the teams.
- To register young researchers in the field of the network.
- Publication of a network bulletin, providing information about scientific events and new scientific results from the network to be distributed in particular to all registered applicants.
- To encourage and arrange *dissemination* of results, lecture notes and proceedings of workshops and conferences. This is done through reports of the team leaders, and provides the basis for a preprint series and subsequent publications (even lecture notes and surveys). Outlets such as the Banach Center Publications or equivalently highly respected scientific series, will be considered.

The CO and Network Administrator will benefit from the extensive experience and expertise of the Mathematics Research Centre at Warwick in organising meetings and conferences, and from Warwick's experience in managing large multi-partner EU grants.

4.1.2 Steering Committee

The Steering Committee (StC), consisting of the team leaders from all 9 partners, meets once a year to decide on issues concerning the scientific and organisational plan of the network. During the first meeting it elects/nominates an Executive Committee, a Scientific Committee and approaches Academic and Industrial Advisers. It decides about the annual budget and initial distribution of funds, within the contract with the EC. Yearly, the StC discusses and decides on:

- Progress towards the scientific objectives, in tasks, and progress in training upon the draft by Scientific Committee.
- Precise topics of workshops and summer schools. Programmes and appointments of organisers of 3 large network conferences and 2 large workshops (1 year in advance).
- The annual financial report from the Network Administrator and fair redistribution of funds.

- Progress in research connected with industry, upon comments from Industry Advisers.
- Asks the Outside Advisers for feedback, ideas and views.

To assist the StC and the CO the following will be put in place:

- An **Executive Committee**, which assists the CO in all major decisions throughout the year, and is responsible for initiating and monitoring of network activities. It consists of the Deputy CO, the chairman of the Scientific Committee, the CO and the Network Administrator. It communicates mainly by e-mail and phone.
- A **Scientific Committee**, which will be set up as a subcommittee of the StC to monitor the network research programme, to draft annual scientific reports, and to advise the StC of actions which might need to be taken in the light of changing circumstances.
- **Outside Advisers**, who will be asked to give an independent evaluation of the scientific directions and network activities.
- **Industrial Advisers**, who will be asked for help to foster existing and new links with industry (see Section 2.2.6), and for advise on the industry related orientation of research and training and on opportunities of collaboration/co-financing (see Section 2.2.4).

4.1.3 Local level

At each site, a **local steering committee** will be set up, to decide about all matters concerning the local network's activities. One of the elected members (the Local Manager) takes care of the network's practical organisation, such as the organisation of meetings, while the Scientist in Charge is responsible for the overall local training arrangements of the network, the early stage researchers and the experienced researchers. The ESR's and ER's will be asked to report annually on their work to the Scientist in Charge, and liaise with their network mentor and the Network Administrator. The financial organisation of the team, including the management of the salaries of the post-doctoral fellows, will be managed by the Scientist in Charge of the team supported by the accountant at the team site. In particular, the tasks are the following:

- Decisions about spending of the local budget (but within network aims).
- Appointing early stage and experienced researchers in cooperation with the Steering Committee.
- Activities planned for the next months.
- Advertising vacant positions and providing information for the network web-pages to the network coordinator.
- Planning of information exchange and cooperation with other teams (joint activities, research, etc...). Fostering and cooperation with local nodes of other networks and programmes in adjacent areas.

4.1.4 Distribution of funds

Since all team leaders have extensive experience in financial management, the bulk of the funds foreseen to be used by the single teams are distributed from the start to satisfy all Team's needs, see the tables at the end of Sections 2 and 7. This has advantages in their management, and gives better planning perspectives for the local steering committees. Nevertheless, the allocated money will often be earmarked for specific training events (such as workshops and so on). The executive committee will control the financial management of the teams and the steering committee can redistribute funds (e.g. for workshops, schools and conferences), if this is appropriate. There is a reserve fund allocated to the network coordinator's team which can be used to provide additional funds if necessary for training purposes. Each team will receive funds for their specific tasks (organization of events, recruiting and

employing early stage and experienced researchers). On top they will receive a fixed amount for their needs in transfer of knowledge activities and another fixed amount for their duties concerning management (e.g. attending organizational meetings). The main part of funds for managing-related expenses will be given to the team of the network coordinator, who is in charge of organizing the internal profile of the network, the outside recognition within the scientific community, and public relations – activities. This team will be supported by a part-time network administrator.

4.1.5 Local and network level

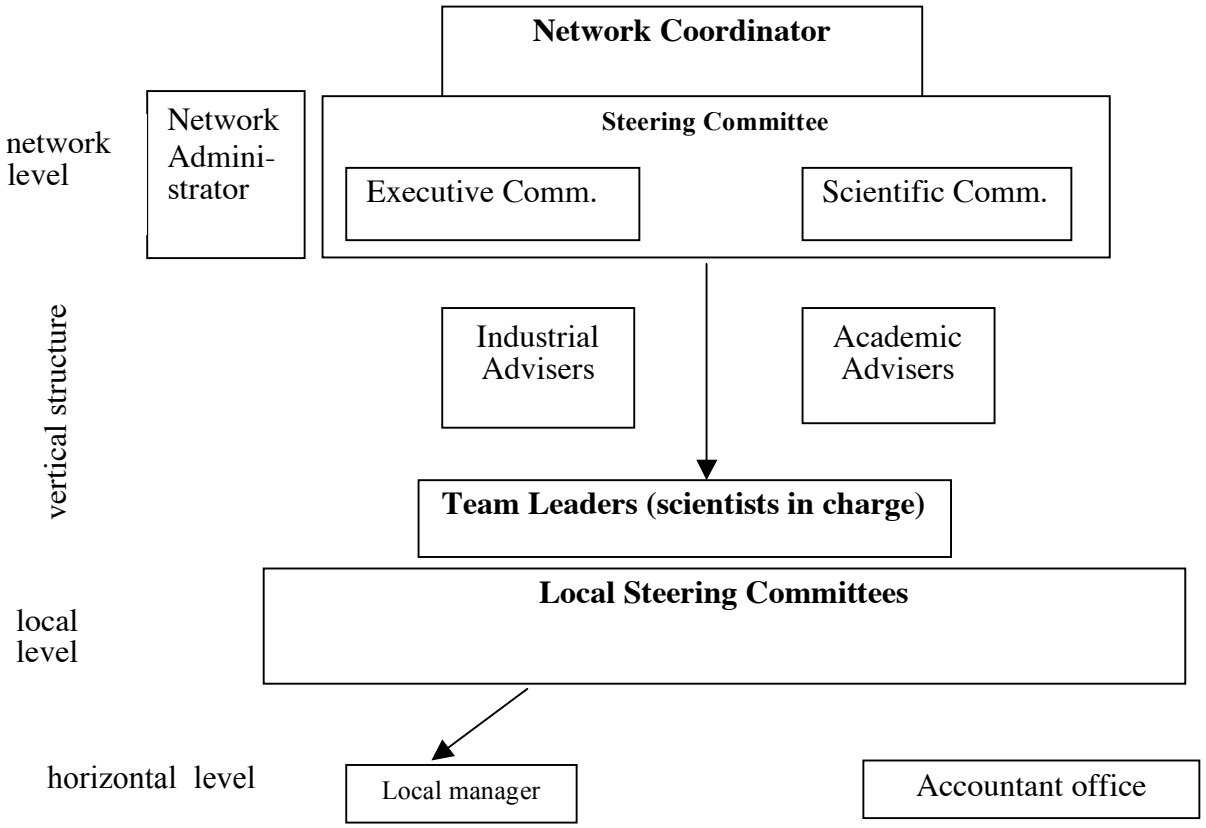

Table 1. Management Organization

At the network-wide level the local needs will be represented by the local scientists in charge; their responsibility will consist in taking care of progress towards the tasks, which includes a report at each panel meeting of StC (or Scientific Committee), the scientific contribution at the Network Conferences (or Large Workshops) of annual talks for each task and, if necessary, the organization of smaller workshops. Local training programme, workshops and summer schools will be organized by local teams.

4.1.6 Allocation of responsibilities

The distribution of management and organizational duties in a network which spreads over so many teams needs to be controlled extremely carefully. For this reason it is important to get the balance between central control (by the Executive Committee) and local independence of the teams right. In order to do this, we want to make sure that the network coordinator and network administrator continuously monitor the way local budget is spent, how local training is performing, progress of

ER/ESR's, planning of local events, and so on. It is essential, that this is done in a way which will be supporting and helpful to local teams. The facilitating role of in particular the network administrator is crucial. This person should play the role as the first point of contact when there are difficulties setting things up. An important role will be for the network coordinator and administrator to provide ideas and help to solve 'tricky' problems that nodes face, and of disseminating best practise among partners.

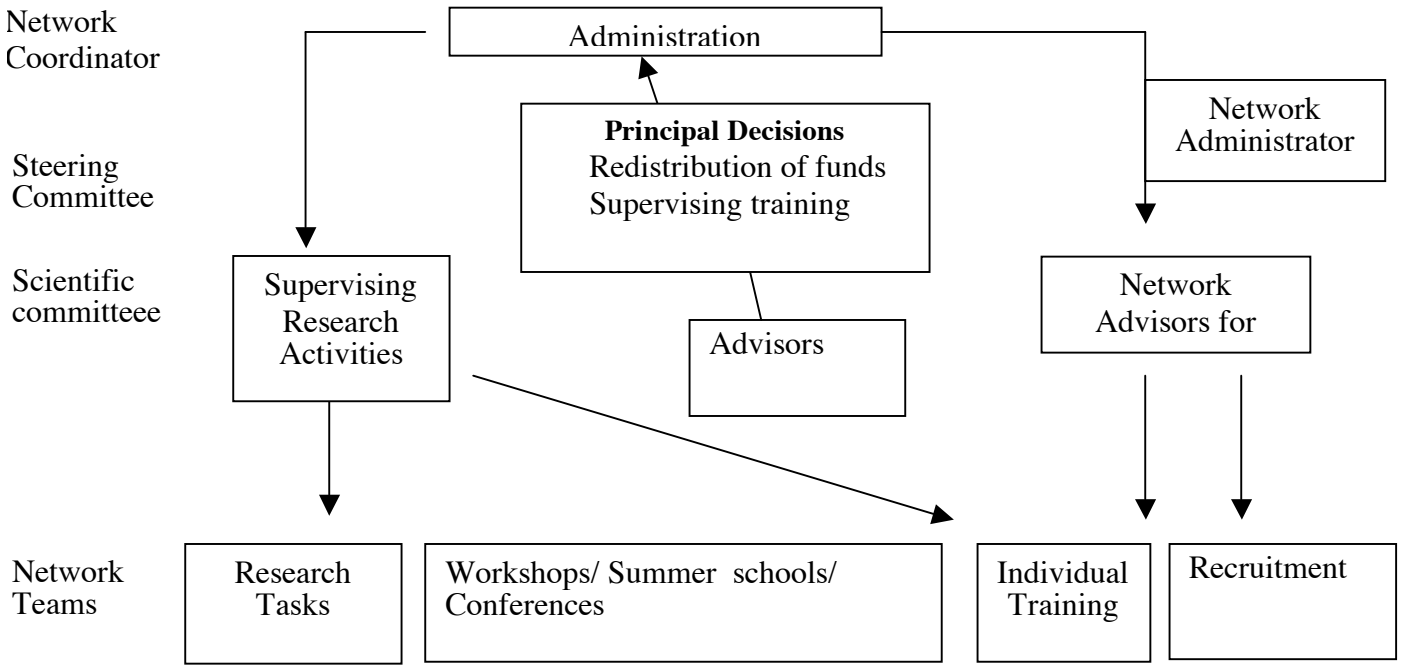

Table 2. Management Duties

4.2 Recruitment, appointment and monitoring procedure

4.2.1 Recruitment and advertisement

Vacant positions and research opportunities will be advertised by electronic media (web page, e-mail distributions), stating eligibility criteria, the mode of selection and a detailed description of the host institution, its infrastructure and measures to promote equal chance research opportunities for men and women. The network will create a **homepage**, which will have a special page for vacancies. The network plans to create **its own electronic bulletin**, in which the positions will be advertised, to be distributed to all participants of the network and experts and leaders of groups outside the network, including non-European countries. A special publicity campaign, through posters and flyers, will be set-up before the start of the programme, to attract the most gifted researchers right from the beginning (most schools are planned for the first 2 years). The network will also be advertising through national and international mathematical societies, in order to inform senior researchers about the special training available within the network (see also Section 2.3). This will include the announcement of workshops and summer schools open to the European mathematical community, and in addition promote the ideas and (in the long term) career opportunities of young researchers in the area. Young researchers in the

area of the network will be **registered** by the network office, so they can be kept up to date of training activities and other opportunities (i.e. jobs).
Furthermore, we will make contact with international partners, such ICTP in Trieste, certain US institutions, IMPA (Brazil) and so on, as they also have well-established training programmes.
Many teams of the network have **female** mathematicians in dominant positions, who clearly have an important role model (and who should be invited to be on interview panels). We hope that this will encourage young female researchers to join the network.
It will also be helpful to provide detailed practical information (about housing, shopping, schools etc.) on the network homepage. The working hours will be flexible (this is standard in mathematics).

4.2.2 Appointment procedure

Applications for positions in the network will be made through the Network Office, who will work closely with local teams. This office will maintain a list of interested candidates, advising them of opportunities. The CV's and reference letters for applicants will be reviewed by the Executive Committee and the local Steering Committee (typically by email), and a pre-selection will be made on this basis. In many cases, applicants will be interviewed by a local committee, and based on all this information, the above committees jointly will decide who to appoint. Minutes of the process will be kept, while keeping gender and other issues into account. After appointment, an ER/ESR will be get the support of a Network Mentor with whom he will set-up a career plan. Typically, short visits and/or secondments will be decided on the level of partners involved.

4.2.3 Monitoring procedures

The Executive Committee and the Network Administrator will make sure that there are regular reports from ER/ESR's, local supervisors, mentors, training reports and budget statements. In addition, these reports will be acted on promptly, if there is any reason for concern.
Similarly, progress on network activities such as training, workshops and so on, will be followed-up regularly by Network Administrator. If there are short-comings, the Executive Committee, and in some cases the Scientific Committee will be asked for advise. The Network Administrator will also act as a facilitator for such events.

4.3. Management know-how and experience of network teams

4.3.1 Network Administrator

As mentioned, it is crucial to appoint an extremely competent (part-time) network administrator. All the teams have extensive training and management skills, but to make sure that the potential added value of the network it is crucial that one has support from an administrator, whose role is to make sure that procedures and monitoring procedures are implemented throughout the running of the network.

4.3.2 The Network Coordinator

The proposed network coordinator, Sebastian van Strien chaired his (former) department during a complicated merging operation, has been chairman of the highly successful ESF programme PRODYN 1998 – 2003, led a Marie-Curie Training Site "Dynamical systems at Warwick", organised numerous conferences and held several large research grants. Also he is managing editor of the journal 'Ergodic Theory and Dynamical Systems'. He has had about 10 PhD students, almost all of whom have been extremely successful, both in academia and in industry. The management infrastructure in Warwick is extensive, as it hosted a large number of FP5, INTAS and other programs, and also some large interdisciplinary networks on mathematics in biology and medicine.

4.3.3 Management know-how of teams and team leaders

As is clear from the list below, all teams in the network have extensive training and management experience. Many sites have had HCM, Marie-Curie, FP5 and ESF programs. Most teams have had large number of PhD students, postdoctoral students (including through the EU Marie-Curie programme). There is a high level of professionalism and spirit of excellence in the proposed network. Together with the procedures described above, all ingredients are in place for an extremely successful network.

Polish Team. Feliks Przytycki, has been scientific director of IMPAN, member of its Board of Directors, co-ordinator of the Centre of Excellence IMPAN-BC (2000-2004) and the co-ordinator of the Marie Curie Training Site BANACH 2000-2004. He also organised many conferences.
French Team. Michel Zinsmeister chaired his department, was director of CNRS team, local coordinator of HCM programme and organised numerous conferences.
Spanish team. Nuria Fagella organised numerous major international conferences, and team members were local coordinators of HCM programs and FP5 programs.
German team. Walter Bergweiler organised several conferences and was team leader of an INTAS programme. Dierk Schleicher has been responsible for building up the Mathematics Department at IU Bremen and organised several conferences. international conferences. Manfred Denker has been responsible for several very large research grants, and organised some extremely successful large workshops and conferences.
Danish/Swedish Team. Carsten Lunde Petersen has organized several conferences, and Bodil Branner was formerly vice-president of the European Mathematical Society and president of the Danish Mathematical Society. The Swedish team at KTH (in particular Michael Benedicks) has been involved with organising a number of highly successful conferences at KTH and Mittag-Leffler, and helped in hosting the European Congress of Mathematics in 2004.
Swiss Team. Stanislav Smirnov was coordinator of a joint network with the US. Others of the team, such as Jean-Pierre Eckmannn, have extensive experience in networking, organization of the Borel seminar, conferences and workshops, as well as schools for graduate students.
Finnish Team. Kari Astala is currently the president of the Finnish Mathematical Society, while Kupiainen is a former president of the society, and Matilla is the leader of a Finnish Centre of excellence. Team members acted as scientific leaders at the Mittag-Leffler institute, and organised many conferences.
Greek Team. Antonio Bisbas is a member of several research Committees and organized two conferences in analysis, and chaired his department.

4.3.4 Relationship of node with the rest of team

The contractual arrangement will be that money will be distributed (as described in Section 6) to the scientific institutions in which the team leaders are based. If it is more appropriate that, for example, an ER or ESR works in another institution associated to a team, the money will be reallocated accordingly.

SECTION 5 – ADDED VALUE TO THE COMMUNITY AND RELEVANCE TO THE OBJECTIVES OF THE ACTIVITY

5.1 Contribution of network to capacity to train and transfer of knowledge needs

The research topic of the network: local self-similar structure of fractal spaces, objects or processes, by methods of space-time conformal rescaling, is highly interdisciplinary, and lies in the interaction between apparently very different areas of mathematics and physics whose common denominator is the notion of conformal or quasiconformal structure.

The main purposes of the network are to

- Overcome the over-specialisation in research topics, which is hindering progress because the common ideas between the analysis, dynamics and mathematical physics topics (of conformal structures) are far from fully exploited;
- To overcome the fragmentation in teams, often even within countries, not aware of each others work and not sharing training or expertise;
- To strengthen contact with industry, which is in particular important since this research area potentially has so many more applications (to network problems, medical applications, usage of ideas from fractal geometry in engineering, …. see also Section 2.2.6).

By creating a network there is real potential for creating a world-leading research area:

Top education and knowledge transfer. The network includes outstanding mathematicians such as Carleson (Sweden), Yoccoz (France) or Smirnov (Swiss), each having great achievements in most of the research topics of the network, and also famous physicists associated to the network: Cardy (UK), Duplantier (France), Gawedzki (France). The network comprises one Fields medallist, one Wolf Prize medallist, four Salem Prize winners of recent years, and many other outstanding experts in the field. This guarantees the supervision by top class scientists and awareness all recent developments, and the potential for world-leading research throughout the network in all topics.

Mathematical and interdiscplinary interaction. As was already pointed out, many of the most exciting results come from ideas which cross different research areas. (For example, Astala's[3] proof of the Gehring-Reich conjecture (A) makes decisive use of dynamical systems' techniques (D).) Encouraging this multidisciplinarity will be the "engine" of the proposed network. The network will also try to overcome barriers between physicists and mathematicians from different fields, by hiring across these fields; the steering committee will also insist on a strong training programme in physics. One drawback of the **barrier between mathematics and physics** is the fact that publications in the different fields happen in very different journals making it, for example, hard for a mathematician to be aware of results by physicists. By providing a joint mathematics/physics preprint database, the network will make collaboration easier. The proposed area on the **interface** of mathematics and theoretical physics with many potential applications will attract very talented young people from all Europe and other countries.

Industrial applications. The industrial potential in this topic area is huge and therefore CODY intends to strengthen bridges between technological applications and mathematics (using existing contacts, current industrial research contracts of team members and the industrial network advisors). Many problems in simulation need structural insight to be tractable. At the same time, deep mathematics arises whenever standard solution techniques fail – multi-scale phenomena being one area of particular relevance. Therefore strengthening the contacts between industry and science will benefit both.

5.2 Impact of research and training network on young researchers and partners

5.2.1. Increasing Human Capital. By building a strong environment in science, we will create the background for teaching mathematical ideas on an interdisciplinary level, meeting the demands for the development of science. The network will promote this goal with the following measures:

Recruitment. We plan to recruit to our network during 4 years 50-70 young researchers for longer stays (in particular to finance 4-8 one-year postdoc positions), encouraging them to visit several teams (secondments) and also encouraging them to apply for more than one appointment during the network's period of existence, see Sections 2 and 4.

Education programme. Besides personal training at the network teams, we plan to organize 10 schools, 10 workshops and 3 large conferences, so the programme will embrace up to about 200 ESR/ER's (and many other young researchers) who are able to benefit from the network. Each ER/ESR will be able to participate in 1-2 schools and 1-2 WS/CF. The training programme will be regionally distributed according to the expertise described at the end of Section 1.

Internationality. The geographical distribution of the nodes is a compromise between the places of highest and broadest expertise, and the need to expand to include, activate and support research and researchers from Less Favoured Regions of EU and associate states. By co-operating with scientists from Brazil, Chile, Russia and Ukraine we plan to attract gifted young researchers throughout Europe, but also Latin America and Asia. Thus we will work to increase Europe's long-term cohesion and world-leadership within this research area.

5.2.2. Benefits of the training network to individual researchers. We expect that the young researchers, who start collaboration during the training and research period within the network's frame, will continue joint research afterwards. Some will become the new leaders, while others go into industry or commerce. By maintaining these links and friendships, a new level of exchange ideas in science and technology will be created.

Career support. Every young pre- or post-doctoral fellow will gain genuine multidisciplinary and solid knowledge and experience that will be positively recognized later by all hiring committees (of universities or other institutions). The network will assist all young researchers, being members of teams or recruited from other places, in applications for research grants or positions (this is addressed in more detail in Section 2.3.4). The role of the network mentor is here extremely important.

Fields of training. The training programme contains elements of importance for industrial applications and thus will prepare, and hopefully even encourage, some of the young researchers to contribute directly to technological developments, based on their mathematical expertise and their analytical ability. We insist that the interacting fields: from analytic tools, through fractals and dynamics, to physical processes, is a perfect choice of mathematical expertise to work successfully in science and industry.

Attracting scientists. As mentioned, the network will attract also Chinese, other Far East and Latin American young researchers, and will encourage the return of some high class scientists from the US, or attracting American researchers to Europe.

Gender issues. The sensitivity to gender issues, and the strength and success of female mathematicians in this network, should help in improving opportunities (and removing obstacles) for women in science.

5.2.3. Long term prospects of the network. As mentioned, the present fragmentation in teams and in research topics is counter productive. Creating a network will provide a framework for developing permanent research collaborations, joint training and so on, and will make young and experienced researchers become aware of the benefits of seeing across areas, of joint work and of having contacts outside small research teams. The benefits of increased contacts with industry will go in both directions, and again should only need initial help from the network. The network's aim will be to set things up for the long-term future.

5.3 European Policies

5.3.1. Objectives towards the European Research Area and European industrial competitiveness.
The scientific and technological bases of industry will be strengthened in three ways.
First, by an **increase of the pool of highly educated researchers**, who are able to contribute basically to all Priority Thematic Areas of FP6. For example their training/knowledge will make them very attractive to be involved in the IST activities, especially in complex systems research, highly related to dynamical systems, statistical physics or robotics, (computer network) traffic analysis and other areas of high quality industry. The network training and research is oriented mainly towards Future and Emerging Technologies, with a long horizon, on a very high scientific "analytical" level, and will encourage contacts with industry through the schools.
Secondly, by **direct or indirect contact**s of senior researchers to partners in science and industry, who are able to spread new promising ideas and methods to their partners. The collection of manpower in this network will lead to breakthroughs in some areas, where applications are quite possible. The transfer of knowledge measurements of network will spread these ideas within and outside the network. Moreover it contributes in a profound way to structuring the European Research Area, by creating the interdisciplinary area on the border of Analysis, Dynamics and Mathematical Physics specified and characterized with the idea of "conformal structures". This will be accomplished by a well organized cohesive framework for the scientific development of young researchers and for their careers. In previous chapters we explained our plans to provide a high scientific level, interdisciplinarity, interregionality and a critical mass of participants in the training programme.
Thirdly, the topics of this network are popular with school children and the general public (fractals, chaos theory,…). Success of the network will filter down through existing popularisation programs (such as those by Ian Stewart [1]). The public appeal of mathematics and physics do need a boost.
5.3.2. Scientific attractiveness and European scientific competitiveness. A well organized network, in a very important interdisciplinary topic like this, will attract many very gifted young people and provides a platform for an internationally recognized scientific education. This will be achieved by the expertise of top scientists, by organizing many meetings of different character and related topics and by excellent research conditions in its node sites. It is also important that the network offers decent financial conditions for the appointed scientists. We expect quite a strong competition especially from the less favoured regions, Russia, Ukraine and other NIS states. Many researchers attracted by the network will prefer to stay in Europe rather than moving to USA, or will be encouraged to return to Europe, especially as the network will try to help in the development of their future career (after the network time). The existence of the network offering a very good programme with top research seminars and attracting excellent young researchers will initiate also returns of experts who left Europe in recent years for better scientific prospects. This is a feedback process which leads to a rapid development of the scientific area. The presence of many top level researchers, and the existence of several transversal training methodologies, gives the potential to create world-leading research in this topic throughout Europe.
5.3.3. Integration of teams from Less-Favoured Regions, Candidate countries and Associate States. One of the principal teams is based in Warsaw, another team is from Makedonia. For geographical reasons, and because they can act as role models, the inclusion of these strong research groups will help to attract some of the best young researchers from Less Favoured Regions, New Member States and Associate Candidate States. In addition we intend to build on existing contacts with groups in Russia, Ukraine, Brazil and Chile, and of course the USA and other highly developed countries.

By our intended web-presence, by registering young interested scientists centrally and thus alerting them of vacancies and opportunities, we intend to create equal opportunities for ER/ESR's throughout the European Union.

5.3.4. Gender issues. As mentioned, the network is well placed to deal effectively with this, for example, by advertising equal opportunities and the ability to provide female scientific network advisors to female applicants and young researchers. Certainly the pre-conditions are in place: for example the Barcelona team leader is female, 5 out of 11 staff in Warsaw is female. This will support the goal of attracting young female researchers to the programme. Network activities of the local teams can encourage female students (before the Master's degree) to pursue a research career.

5.3.5 Cooperation with local, regional and (inter)national research. Many teams have extensive local, regional and international activities. Some of these are present in the description of every team. All teams have their own undergraduate, PhD and postdoc programmes in their universities with which the network will naturally cooperate. In particular, joint research projects, seminars, weekend schools and workshops will be organized with local graduate schools and being announced within the network. In this way additional training can be organized for the benefit of the network.

Several other international networks or programmes operate in adjacent areas (large conferences in the area usually have several sponsors). Let us mention the European Science Foundation programme Probabilistic Methods in Non-hyperbolic Dynamics (1998-2003), which serves as an example of how other programmes (coming into effect during the period of support of this network) will add to the value of this network and provide training in adjacent areas. Apart from the **USA** and **Canada** (Toronto) there are extensive research contacts with (for example) teams in

Moscow. This group gathers basically people from famous "Sinai seminar". Sinai, together with Kolmogorov, Anosov, Arnold, pioneered in 60s the so called thermodynamic approach to dynamical systems. The group actively collaborates in particular with G. Keller[6], S. Vaienti[4], K. Khanin[1], O. Kozlovski[1], S. Kuksin[1], S. Troubetzkoy[4]. This group includes Oleg Ageev, Dmitrij Anosov, Michael Blank, Boris Gurevich, Rustam Ismagilov, Valerij Oseledec, Andrej Starkov, Anatolij Stepin. An example of this collaboration is: M. Blank, G. Keller and C. Liverani,, "*Ruelle-Perron Frobenius spectrum for Anosov maps",* Nonlinearity, 15:6(2002), 1905-1973.

St. Petersburg. Anatoly Versik's group. The main topics: Application of dynamical systems to representation theory. Arithmetic coding and symbolic dynamics. Members of this group include Anatoly M.Vershik, Natalia V.Tsilevich, Andrei A. Lodkin and Konstantin P. Kohas.

Kiev. Sharkovsky's group. In the 1960's, Sharkovsky pioneered the theory of maps of the interval. Members of this group include: Sergiy Kolyada, Andrei Sivak and Volodymyr Nekrashevych.

Instituto de Matematica Pura e Aplicada (IMPA), Rio de Janeiro, Brasil. This is the famous research and training Institute, leading in Latin America. One of its specialities is Dynamical Systems, another Complex Singularities. Several researchers have expertise in the area of the network. Intensive cooperation with Team 3 – Acordo de Cooperaço Brasil – França am Matemática.

Joint publications are with Jacob Palis (former president of the International Mathematical Union, member of the IMU executive committee, one of founders and world leaders in dynamical system), Welington de Melo (Invited speaker at ICM. Expert in smooth dynamical systems and 1-dimensional iteration. co-author of a well-known book with van Strien[1]), Carlos G. Moreira (joint work with Yoccoz[4] and Avila[4]), Enrique Pujals (invited speaker at ICM Beijing 2002), Marcelo Viana (plenary speaker at ICM Berlin 1998).

Santiago/Antofagasta, Chile. This is a young group working including Jan Kiwi, Juan Rivera-Letelier (joint work with F. Przytycki[2] and S. Smirnov[9]), Rodrigo Bamon and Sergio Plaza Salinas.

Individual researchers have also research contacts with **Israel, Romania and Hungary**.

SECTION 6 – INDICATIVE FINANCIAL INFORMATION

The network will apply unified standards for employment and recruitment of early stage and experienced researchers. Early stage researchers will be offered a fixed-amount stipend. We expect that 50% of eligible researchers fall under the trans-national mobility allowance. To encourage female applicants some funds will be allocated for married researchers and researchers of equivalent status.

It will be the policy of the network to encourage mobility of the experienced researchers. Therefore the trans-national mobility allowance applies, and we also expect that the majority of these applicants will be married or have an equivalent status. The form of employment is by contract, since attracting female applicants needs a solid financial background with social security.

On the basis of 252 ESR and 168 ER person-months appointments, the cost for teaching/training and knowledge transfer not related to the recruitment of early stage researchers and experienced researchers (basic living expenses, travel allowance, mobility allowance, one-off career exploratory allowance and research expenses) is broken up as follows:

Column A

Three international conferences, which at the same time serve as overall network meeting, with a budget of 38 000 Euro each to cover travel and living expenses of team members and young researchers, as well as the costs for distributing conference materials, renting conference rooms etc.

Four large workshops in year 2 and 3, with a budget of 15000 Euro.

Six workshops, some of which have already been planned for year 1 and 2, and will have on average of a budget of 10000 Euros, permitting to support about 20 participants.

Ten summer schools. With a budget of 10000 Euro each, partially or full support up to 30 participants.

Short visits to other teams in the network will support knowledge transfer, and will be budgeted for 6000 Euro for each team for ESR and ERS. For the related costs for experts see Column B.

Column B

Travel by experts: 6 000 Euro per team

Reserve funds: an amount of 49 000 Euro will be kept centrally in Warwick to support schools and workshops which have more applicants or turn out to be more costly for other reasons.

Column C

Financing of management activities include the following issues:

Network coordination in Warwick, including the cost of a (part-time) network administrator, administration costs, travel support for members of the Executive, Scientific or Steering Committee. This is budgeted as 125000 Euro.

Local expenses of network teams, which included costs associated to interviewing candidates, maintaining local webpages, and some administrative overheads, but also managing certain local activities (local travel costs). This is budgeted as 8000 Euro.

Column D activities are not requested.

Indicative financial information on the network project (excluding expenses related to the recruitment of early-stage and experienced researchers)								
Network Team No.	Contribution to the research/ training / transfer of knowledge expenses (Euro)						Management activities (including audit certification) (Euro)	Other types of expenses / specific conditions (Euro)
	(A)					(B)	(C)	(D)
	CF	LWS	WS	Sch	V			
1.U. Warwick	38 000		10 000		6 000	55 000	125 000	-
2. IMPAN	38 000			10 000	6 000	6 000	8 000	-
3. U.Helsinki			10 000	10 000	6 000	6 000	8 000	-
4. U. Orleans	38 000		10 000	10 000	6 000	6 000	8 000	-
5. U.Barcelona		15 000	10 000	10 000	6 000	6 000	8 000	-
6. U. Kiel		15 000	10 000	10 000	6 000	6 000	8 000	-
7. R.U.C.		15 000		10 000	6 000	6 000	8 000	-
8. TEI			10 000	10 000	6 000	6 000	8 000	-
9. U. Genève		15 000		10 000	6 000	6 000	8 000	-
Totals	368 000					103 000	189 000	-

CF – Conference
WS – Workshop
LWS – Larger Workshops
Sch – School
V – Short Visits/ Secondments

Totals

Expenses related to the recruitment of 252 ESR and 168 ESR	Host organizations			Total
	TK expenses (A+B above)	Management activities (C)	Overhead	
1 825 836	471 000	189 000	229 684	2 715 520

SECTION 7 – PREVIOUS PROPOSALS AND CONTRACTS

This proposal is resubmission of the proposal FP6-005506. This proposal received the following marks: 4.8/5 Scientific Quality, 4.6/5 Quality of Training, 4.5/5 Quality of Network Partnership, 3.5/5 Management and Feasibility, 4.3/5 Relevance of Activity, 4.1/5 Added Value to Community, with a total score of 86.3. The main critisicm of the referees was related to the large number of teams, and to perceived weaknesses in the proposed management structure. To address these issues, our management plans have been completely revised: much more robust and thorough management and quality monitoring have been put in place. Many other aspects of the proposal have also been improved.

The ESR/ER ratio which was proposed in the Outline proposal in stage 1, was adjusted following a recommendation of a referee and other advise.

The proposal is loosely connected to HCM "Conformal Geometry and Geometric Function Theory", ERBCHRXCT920071, but is much more interdisciplinary in nature.

SECTION 8 – OTHER ISSUES

There are no ethical or safety issues associated with the project that we are aware of.

This area of mathematics (connected to fractals, chaos, visualisation of scaling) is extremely suitable for popularization, video presentations, exhibitions and popular talks. Some such activities are already taking place (Stewart (UK), Bergweiler & Koch (Germany), Days of Science (Poland), Videos (Douady, France)). The network will encourage such activities.

Does the research presented in this proposal raise sensitive ethical questions related to:	**YES**	**NO**
Human beings	-	NO
Human biological samples	-	NO
Personal data (whether identified by name or not)	-	NO
Genetic information	-	NO
Animals	-	NO

ENDPAGE

HUMAN RESOURCES AND MOBILITY (HRM)
ACTIVITY

MARIE CURIE ACTIONS
Research training networks (RTNs)

PART B

CONFORMAL STRUCTURES AND DYNAMICS

CODY