

**2009 / 2010
Master Classes**

**ARITHMETIC GEOMETRY
AND NONCOMMUTATIVE
GEOMETRY**

**NUMERICAL BIFURCATION
ANALYSIS OF DYNAMICAL
SYSTEMS**

**INTERNATIONAL MASTER
SEMESTER
GEOMETRY IN THE SCIENCES**

M

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INSTITUTE

MATHEMATICAL RESEARCH INSTITUTE

There is something paradoxical about mathematical research. Unraveling a mathematical problem is a highly individual activity, but it is precisely in discussion with colleagues that questions and problems emerge. Interaction is crucial.

In 1992, four of the leading mathematics departments of universities in the Netherlands joined forces to form an inspiring platform for interaction by founding the Mathematical Research Institute (MRI). In doing so, the universities of Groningen, Nijmegen, Twente and Utrecht have further reinforced the position of Dutch mathematical research, the quality and productivity of which is ranked in the European top. The MRI covers a broad range of specializations, with emphasis on four central areas in mathematics: algebra and geometry, analysis, stochastics and operations research, history/education. The MRI's research is characterized by its attention to the dynamic relationship between fundamental and applied aspects of mathematics. In order to stimulate the quality and the development of its research, the MRI pays a great deal of attention to education and training of researchers.

All partners of MRI are directly involved with its programmes - this guarantees a high level of quality. MRI also has excellent connections in The Netherlands and abroad and regularly invites guest lecturers. This multi-faceted and international atmosphere allows students to get the most out of different visions: an inspiring and challenging situation.



MRI ACTIVITIES

The Master Class (one year) occupies an important place in the MRI's programme of studies. It is open to anyone in the final years of their undergraduate studies, and also to graduate students. These courses offer a unique opportunity for mathematical talent to develop in the context of current topics that vary annually.

The Master Class is specifically aimed at an international audience, and has proved to be successful in bringing together Dutch and foreign students. The language of instruction is English, which makes these schools accessible to foreign students. Since recently, most of the Master Classes are affiliated with one of the national research programmes ("clusters") supported by the Netherlands Organization for Scientific Research (NWO), or are organized in collaboration with the Thomas Stieltjes Institute for Mathematics.

The final application deadline for the 2009/2010 Master Class is JANUARY 1/APRIL 1, 2009, by which dates applications and the necessary documents must have been received by the MRI.

FOR CANDIDATES WHICH APPLY FOR A FELLOWSHIP OR VISA, THE DEADLINE IS JANUARY 1, 2009.

MASTER CLASS

In the one-year-long Master Class, a current topic is studied intensively and profoundly at an advanced level. The Master Class can form a significant contribution to a PhD programme or preparation for one.

The programme runs from September through June and includes two full days of lectures and seminars per week and individual work on a test problem. The emphasis is on independent, individual effort, but contact with lecturers is personal and intensive. Lecturers give feedback using the work turned in by participants, as well as extensive exercise material. There is a weekly consultation hour for individual questions. Regular evaluation and testing guarantees the quality of the programme. Students who complete the courses successfully will be awarded a Master Class Certificate.

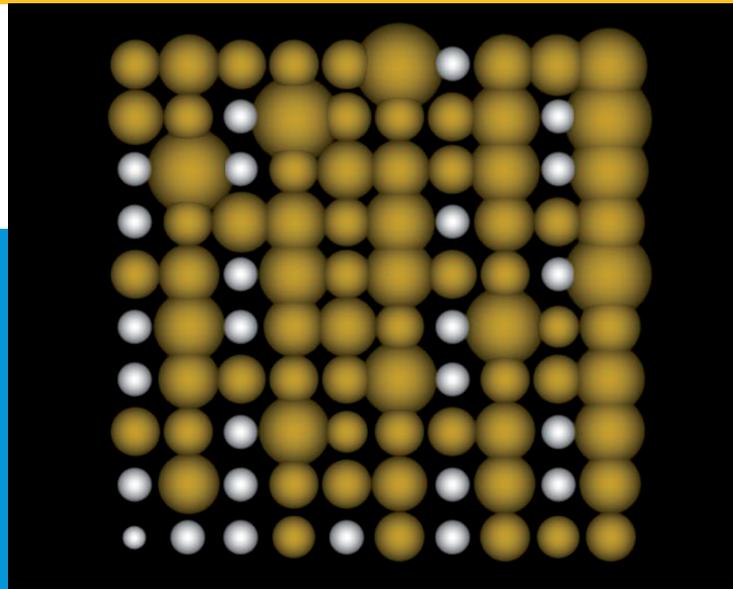
Candidates will be selected on the basis of previous academic achievement and references from their home universities. Admission and tuition fees for the Master Class are € 2269. The cost of a modest but pleasant stay in The Netherlands, including residence and insurance, is approximately € 800 per month. In addition to the cost of travel to and from The Netherlands, an extra amount of € 700 will be needed to cover travel expenses in The Netherlands to and from the locations of supplemental educational activities. Participants needing financial support are requested to approach potential sponsors individually, through their own universities or international institutions. See also: www.nuffic.nl/huygens.

In a few cases, the MRI may be able to help with applications for a stipend. The MRI itself only offers a limited number of stipends.

ARITHMETIC GEOMETRY AND NONCOMMUTATIVE GEOMETRY

The past decade has witnessed a lot of interaction between number theory, arithmetic geometry and noncommutative geometry. To name but a few examples: Manin's real multiplication programme, Consani and Marcolli's recast of Arakelov geometry in terms of spectral triples and Connes and Marcolli's reformulation of explicit class field theory in a noncommutative thermodynamical formalism. One observes how these examples each nicely hook noncommutative geometry to one of the significant trends in modern number theory and geometry.

At the same time, noncommutative geometry is further extending its (controversial?) scope in mathematical physics, more precisely in renormalisation (explaining the occurrence of such number theoretical gadgets as Tate motives therein) and the standard model. The master class will lead students to the forefront of this research field. The structure is to offer courses on basic noncommutative geometry in connection and interaction with a variety of background material from traditional mathematics. The first semester has an introductory programme. The basics of C^* -algebras are taught, with special focus on the examples that occur in number theory (such as crossed product algebras, Cuntz-Krieger algebras). There is a course on analysis of pseudo-differential operators on manifolds (with an eye towards Dirac operators). A student seminar is devoted to uniformisation of Riemann surfaces and Kleinian groups, and a basic course on ergodic theory culminates in Hopf's theorem on ergodicity of geodesic flow.



J-F. Colonna

The second semester starts with a topics course in number theory, half of which is about p -adic numbers, and half of which is on the theory of zeta functions (broadly interpreted). There is a basic course on noncommutative geometry, dealing with some K -theory of operator algebras, spectral triples and noncommutative tori. Finally, there is a student seminar on spectral triples in which some of the original papers will be read. This is complemented by expert lectures (Master Class within the Master Class) by Consani, Marcolli, Robertson and van Suijlekom.

For more information, see

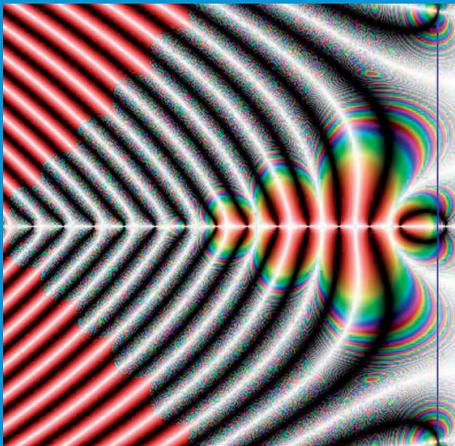
<http://www.math.uu.nl/people/cornelis/mc.shtml>

This Master Class is affiliated to the research cluster GQT (Geometry and Quantum Theory), supported by NWO.

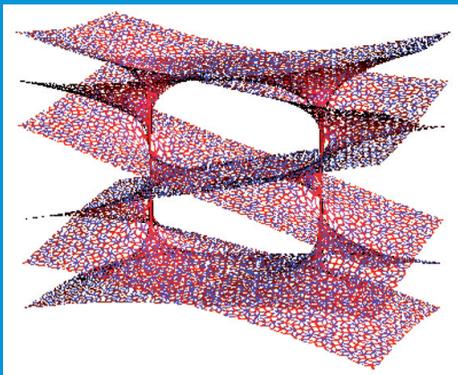
PREREQUISITES

Applicants should have completed at least three years of undergraduate studies in pure mathematics or theoretical and mathematical physics.

Students are assumed to know some basic functional analysis (Hilbert space) and theory of differentiable manifolds. If necessary, a crash course on these topics will be organized before the start of the Master Class.



J-F. Colonna



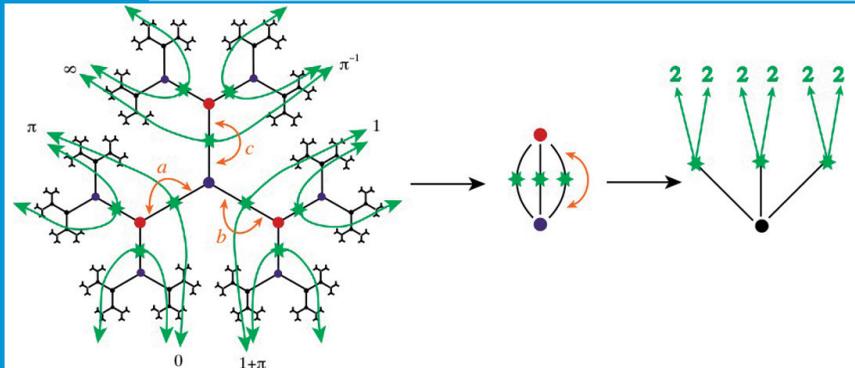
COURSES

First semester

- C^* -algebras
Lecturers: E. Koelink, N.P. Landsman (RU Nijmegen)
- Analysis on Manifolds
Lecturers: E. van den Ban, M. Crainic (Utrecht)
- Ergodic Theory - Dynamics on Manifolds
Lecturer: K. Dajani (Utrecht)
- Seminar: Kleinian Groups and Riemann Surfaces

Second semester

- Topics in Number Theory: p -adic numbers and zeta functions
Lecturers: R. de Jeu (VU Amsterdam), F. Beukers (Utrecht)
- Noncommutative Geometry
Lecturers: E. Koelink, N.P. Landsman (RU Nijmegen), J. Plazas (Utrecht)
- Master Classes within the Master Class
Lecturers: C. Consani (Johns Hopkins), M. Marcolli (Caltech), G. Robertson (Newcastle), W. van Suijlekom (RU Nijmegen)
- Seminar: Spectral Triples

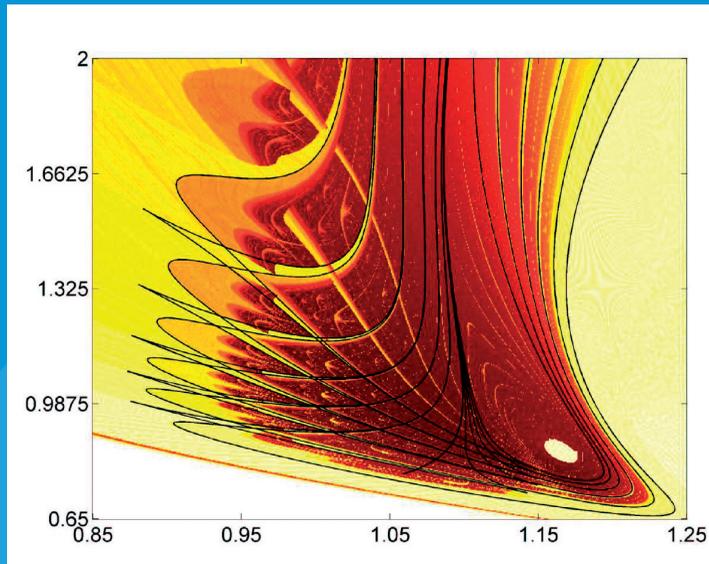


NUMERICAL BIFURCATION ANALYSIS OF DYNAMICAL SYSTEM

Nonlinear dynamical models appear in many branches of modern science, from physics to biology and economics, where they describe the evolution of the system state in time. Such models also play a crucial role in an increasing number of technological, environmental, and social applications. The analysis of a complex dynamical model is impossible without computers. Traditionally, such models have been studied by simulating their evolution for a small range of scenarios. Nowadays, however, the focus has shifted towards classifying the types of behavior that a dynamical system can exhibit as a function of its parameters. Particularly interesting is to study qualitative changes (called bifurcations) in the model behavior under parameter variations.

The last decade showed a rapid progress in the computer-assisted bifurcation analysis of dynamical systems generated by ODEs and maps, both in the numerical methods and in the software. New, or significantly improved, algorithms have been proposed and implemented into the standard software tools (AUTO-07p, MatCont, DsTool, DDE-BIFTOOL, SlideCont, LOCA, etc.), including the continuation and normal form analysis of limit cycles without explicit construction of the Poincaré map, continuation of orbits homoclinic and heteroclinic to equilibria and cycles, computation of one- and two-dimensional invariant manifolds, branch switching at local bifurcations to global objects, numerical analysis of piecewise-smooth and delay ODEs, continuation of equilibria and cycles in large ODEs, etc. These developments have not yet been presented in textbooks and, therefore, are insufficiently used in applications of dynamical systems theory.

This Master Class is aimed at bridging this gap. It will transfer the unique knowledge accumulated by experts in numerical bifurcation analysis to young graduate students. It will provide an intensive advanced-level training in numerical analysis of dynamical systems (theory and software), with focus on finite dimensional smooth ODEs and iterated maps.



O. De Feo

The program will include basic courses on bifurcation theory and numerical methods for bifurcations (in the first semester), as well as more advanced mini-courses covering specific topics, such as the continuation of homoclinic bifurcations, computation of invariant manifolds, bifurcations in non-smooth ODEs and DDEs, and dynamical models in biology (in the second semester).

The Master Class runs from September 1st, 2009 until June 30th, 2010.

PREREQUISITES

Applicants should have completed at least three years of undergraduate studies in mathematics or theoretical physics. Students are assumed to be familiar with linear algebra and to know basic results on ordinary differential equations (ODEs).

For more information see:

<http://www.math.uu.nl/people/kuznet/mcnbds.html>

This Master Class is affiliated with the research cluster "Nonlinear Dynamics of Natural Systems" that is funded by NWO.

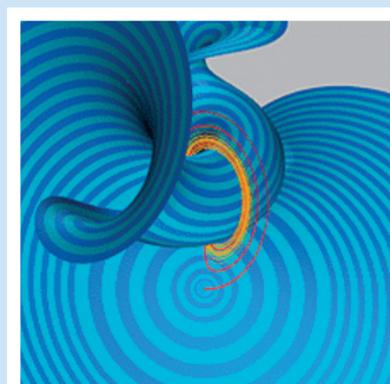
COURSES

First semester

- Dynamical systems generated by ordinary differential equations and maps
Lecturers: O. Diekmann and Yu.A. Kuznetsov (Utrecht)
- Introduction to numerical bifurcation analysis of ODEs and maps
Lecturer: Yu.A. Kuznetsov (Utrecht)
- Numerical bifurcation analysis of large scale systems
Lecturer: F.W. Wubs (Groningen)

Second semester

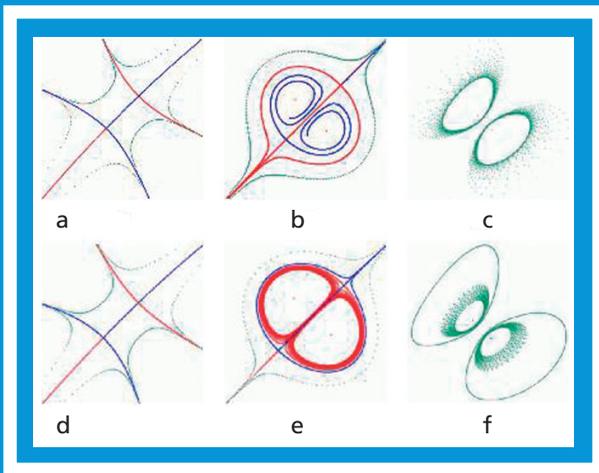
- Mathematical evolution models in the life sciences (W. Govaerts, Gent)
- Numerical bifurcation analysis of population dynamics (B. Kooi, Amsterdam)
- Bifurcation analysis of ODEs with delays (D. Roose, Leuven)
- Continuation of homoclinic bifurcations of equilibria (A. Champneys, Bristol)
- Computation of periodic orbits in conservative systems (E. Doedel, Montreal)
- Computing invariant manifolds via the continuation of orbit segments (H. Osinga, Bristol)
- Advanced numerical bifurcation analysis of maps (H.G.E. Meijer, Enschede)
- Numerical analysis of bifurcations in Filippov systems (Yu.A. Kuznetsov, Utrecht)



H. Osinga

GEOMETRY IN THE SCIENCES

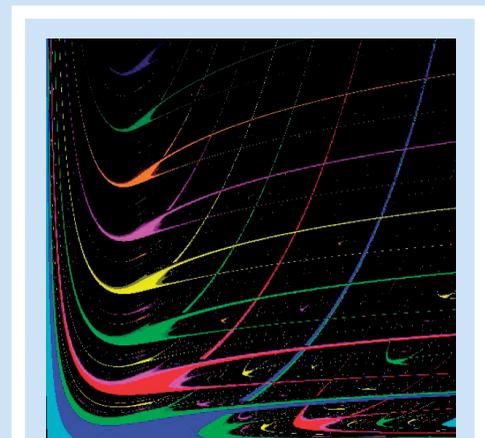
This is a one semester programme, where a current topic is studied intensively and profoundly at an advanced level. The aims are similar to those of the Master Class, the main difference being that the international master semester is shorter and more intensive. In this way the International Master Semester is more suitable as an activity complementary to ongoing studies at the home university. The programme can form also a significant contribution to a PhD programme or preparation for one.



H.G.E. Meijer

Courses:

- Geometry and Physics
Lecturer: H.W. Boer
- Singularity Theory and its Applications
Lecturer: D. Siersma
- Discrete and Computational Geometry
Lecturers: G. Vegter, M. de Berg
- Student Seminar
Various speakers



N. Davydova

For more information see:

<http://mri.math.uu.nl/education/education-ism.html>

Application deadline: 15 september 2008

STUDYING IN THE NETHERLANDS

The kingdom by the North Sea with its mild climate has been an international meeting point for scientists and artists for centuries. The well-known wooden shoes and windmills are charming stereotypes, but knowledge and science represent a larger part of The Netherlands' international trade than Dutch cheese and tulips. There is a long tradition of university research and education in The Netherlands. The oldest Dutch universities have their roots in medieval times. Through the centuries, the universities have developed from monks' schools into modern research and educational institutions.

Higher education is a fundamental component of Dutch culture, and studying in The Netherlands has become more than simply following courses: it has become a way of life. The scientific climate in The Netherlands is open and communicative. The relationship between students and lecturers, and among students themselves, is less formal than in many other countries. Student life offers opportunities for culture, sport and recreation. Foreign students will find that a well-organized and lively student life and a tolerant national culture make for a pleasant period of study in The Netherlands. Language need not be a problem, as virtually all Dutch people speak English.

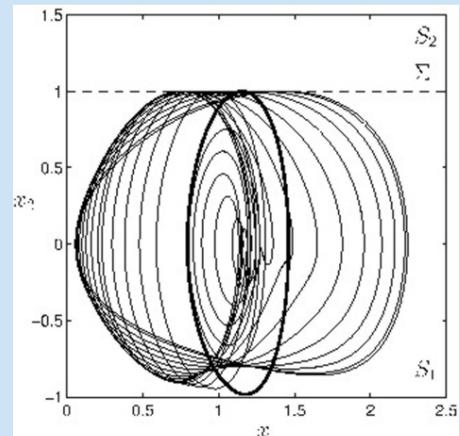
STUDYING AT THE MRI

The participating universities are located in Groningen, Nijmegen, Twente and Utrecht, each with its own special attractions. Often the courses take place in two of these four universities.

The MRI helps students find housing in one of the four cities, on campus or in a studenthouse. Participants in the Master Class and Spring School have full use of the university facilities, such as excellent libraries and computers with Internet connection (e-mail).

Benno van den Berg (The Netherlands), former PhD student in Utrecht, participant in the 1998-1999 Master Class:

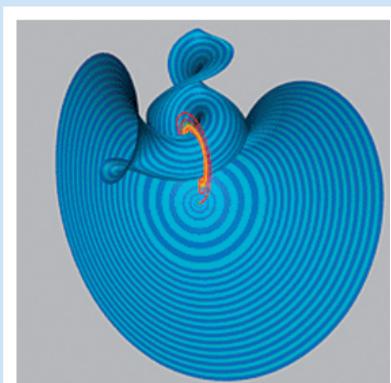
When the MRI organized a master class in Mathematical Logic in the year 1998/99, it came at just the right time for me. I was interested in graduating in mathematical logic and the Master Class offered introductory and advanced courses in a wide variety of topics. During a very pleasant year I not only learned new mathematics, but also knew people from all over the world. I especially enjoyed working on demanding exercises together with some other students. It was also very useful for me to learn the "logical landscape" in Holland, who the logicians in Holland were and what they were doing, especially as I am Dutch. When I was doing a PhD in Utrecht in one of the topics taught during the master class, I realized that courses in some topics, like mine, are actually quite rare. I appreciate how helpful it was to be introduced to that subject in such an enjoyable way.



F. Dercole

Camilo Arias Abad (Colombia), participant in the 2003-2004 Master Class, PhD student in Utrecht:

I truly enjoyed the Master Class in Noncommutative Geometry held in Utrecht/Amsterdam in 2003-2004. Since the beginning it was clear that the lecturers would be of the highest level, that courses would be difficult and that we were expected to work a lot. I also realized soon that my classmates were all (as I am) genuinely interested in mathematics, this resulted in many useful discussions and made my stay in Utrecht much more interesting and pleasant. It was very easy to talk to the professors and ask them very frequently questions, I learned a lot from close contact with them. Also, people at the department were very kind and helpful. After the Master Class, I came back to Utrecht as a PhD student. Now I have even closer contact with professors and fellow students, enjoy the mathematical discussions, questions and seminars and also, non-mathematical discussions, chess and football games. This is really the kind of environment I like to study in.



H. Osinga

Javier Fernandez de Bobadilla de Olazabal (Spain), participant in the 1996-1997 Master Class, former PhD student in Nijmegen/Utrecht, former PostDoc in Utrecht:

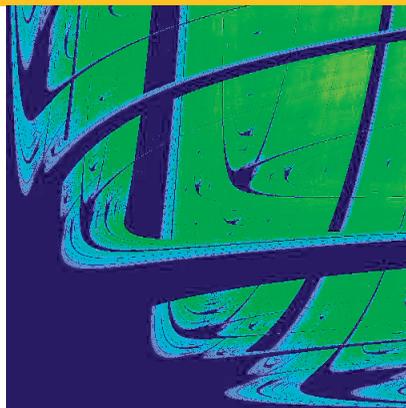
I participated in the 1996/1997 Master Class in Complex Geometry and Topology. The quality of the programme was very high. The courses were well selected, broad and deep. The lecturers knew how to go direct to the heart of the matter in each course. Moreover, I found the test problem an excellent way to get immersed into a research topic and make a first contribution. In fact, my current research interests are more related with my test problem than with the topic of my PhD thesis.

Besides the Master Class itself one can benefit very much from the scientific environment of the MRI. There are leading experts in many fields of mathematics, and interesting courses, seminars and talks are organized on a regular basis. Actually, like many other Master Class students, I continued my stay in MRI until I finished my PhD, and I further continued my stay in The Netherlands on a PostDoc position. I have no doubt that Master Class has been a corner-stone of my career.

Milad Niqui (Iran), participant in the 1998-1999 Master Class, former PhD student in Nijmegen, Postdoc in Nijmegen:

In 1998, after obtaining my first degree in mathematics in Iran, I heard about a one year activity organized by the Mathematical Research Institute in the Netherlands. I was lucky; because in this year the topic was mathematical logic. This was a topic that had fascinated me during my undergraduate studies. I had already heard about the strong tradition of logic in the Netherlands and knew a bit about the intuitionism of Brouwer. I also liked the proposed subjects that seemed to cover all major areas of logic as mentioned in the “Handbook of Mathematical Logic”.

Furthermore, I was excited by the possibility of spending a year in another country. So I applied without hesitation and I was very happy when I got admitted. When I finally attended the course the first thing that amazed me was the close interaction between teachers (some of them well-known names to me because I had seen their books when I was undergraduate student) and the students. Each subject had a teaching session followed on the same day by an exercise session. The exercise sessions really helped in comprehending the ideas that we had learnt during the class. You got to have a more personal interaction with the teacher, as well as discuss the exercises with other students. The courses and most of the students were based in Utrecht, but some of the courses were held in Nijmegen. The fact that we spent one day a week in Nijmegen (some 70 kilometers away) made the course even more interesting: regularly we got to spend some time in another university, and a lot of talking about the courses was done during the train trips.



N. Davydova

I also liked the fact that I got to know fellow Master Class participants who shared my interest in mathematical logic. We learnt a lot from each other by exchanging ideas and talking about our own favorite points. Some of the participants were already PhD students and many of them became my fellow PhD students and colleagues later. At the end of the one year course I was offered the possibility to start PhD studies in Nijmegen under the supervision of two of the teachers of the Master Class Henk Barendregt and Herman Geuvers. I am now still working as a post-doc researcher in theoretical computer science in the same research group in Nijmegen. Participating in this Master Class made me familiar with a serious research environment in which people were doing pioneering research. Also the knowledge I got from attending the courses is invaluable. During my PhD studies I sometimes had to consult my Master Class notes on some of the subjects which were not directly the focus of my PhD project, but were closely related. In short, I should say that this Master Class played a central role in shaping my academic career. Based on my experience, it is an ideal starting point for students who want to pursue a serious research career in logic or theoretical computer science.

APPLICATION

The application deadline for the 2009 / 2010 Master Classes is January 1, 2009. For the Master Class candidates that do not apply for a fellowship or visa, the deadline is extended to April 1, 2009.

The deadline for the International Master Semester 2009 is September 15, 2008.

To apply for the Master Class or International Master Semester please send the following documents to the secretariat of the MRI:

- curriculum vitae (including the following details: first name, surname, date of birth, nationality, address, postal code, city, country, phone number, fax, email address)
- academic record: list of subjects/classes/marks taken at university, subjects for degree examination, photocopy of diploma (if available).
- recommendations from members of the academic staff of the home university (at least one)
- a summary of financial circumstances (if financial support is necessary).

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Applications for the Master Class & International Master Semester should be sent to:

Helga Hoiting
Utrecht University
P.O. Box 80010
3508 TA Utrecht
The Netherlands
Phone: +31-30-2531515
Fax: +31-30-2518394
e-mail: science.secr.mathinst@uu.nl
website: <http://mri.math.uu.nl>