

# Detailed Proposal Information for Marie Curie Training Site (CADEPA)

## ***1. Description of the Doctoral Training***

### **1. Significance of the Training Proposed**

Training site fellows will be treated essentially the same as our other graduate students. The training proposed will consist of pursuing a supervised research project on a topic to be agreed by the fellow so as to complement their programme at their home institution, which we expect to involve a combination of theory and computer programming. This will be supported by attendance at lectures offered within the postgraduate programme of the University of London, and by participation in our group seminars and discussion meetings.

The group is one of the REDUCE development sites and has contributed a number of the packages that are currently distributed with REDUCE. We therefore run the current development version of REDUCE and have full source code, and we are in regular working contact with the implementers and other principal developers. We have considerable experience of teaching algebraic computing at both undergraduate and graduate levels, having introduced our first course based on REDUCE in the mid 1980's. We also have expertise in Maple, which is our current undergraduate teaching language. Members of the group also contribute code to the GAP and MAGMA computer algebra systems, giving us access to the latest versions and inside knowledge of these systems.

Computer algebra has been slower to develop than other branches of computing because until quite recently it required more computing resources than were readily available. It is therefore a field in which a lot of fundamental problems remain to be solved, and one that has seen fairly explosive growth over the last 10 years.

Algebraic data is much harder to display and communicate than numerical or simple text data. Modern computer algebra systems have good local display facilities, but remote display via the web and communication between different computer algebra systems are current active research problems, which are being addressed by the development of the MathML mark-up language and the OpenMath communication protocol. Members of the group have interests and some involvement in this area. For example, we run web-based differential equation demonstrations that display typeset mathematics remotely using T<sub>E</sub>X (which was available and stable long before MathML began to be developed) as intermediate display language.

### **2. Benefits of the Proposed Training Site**

The fact that the group is actively involved in the development of more than one CA system (REDUCE, GAP and MAGMA) and also actively uses at least one other CA system (principally Maple) gives us an unusually wide perspective, from pure mathematics through to numerical applications. Members of the group also have peripheral expertise in areas such as artificial intelligence and genetic algorithms (Computer Go), user interfaces and syntax-directed editors (an Emacs integrated development environment for REDUCE).

We therefore offer a very stimulating but supportive research environment in which graduate students are exposed to a wide range of experiences and viewpoints that will make them better able to lead others in the field. Their breadth of vision will be enhanced and they will have the opportunity to be supervised by leading researchers with considerable experience of directing pre-doctoral studies.

London is well placed for access to the rest of the UK (and, indeed, elsewhere). In particular, we are quite close to other UK university centres of expertise in computer algebra at Cambridge, Bath and Kent, with whom we have strong academic links. We also have good links with the GAP developers at the University of St. Andrews and REDUCE developers at ZIB in Berlin.

We are close to many of the other colleges of the University of London, and many seminar programmes are inter-collegiate. There is also the possibility to study courses taught at other colleges. London is also, of course, a major cultural centre.

The University of London has a very long history of accepting foreign students, so that students from continental Europe will not feel at all out of place and we have a well-developed infrastructure in place to accommodate foreign students. For example, our Learning Development and Continuing Education Unit offers a range of English language and study skills programmes.

## **2. Description of the Training Site**

### **1. Presentation of the Institution**

Queen Mary and Westfield College is one of the constituent colleges of the University of London. It is a multi-faculty institution with over 8,000 students. All departments except clinical medicine are on a single campus in East London.

The School of Mathematical Sciences has about 40 full-time permanent academic staff and corresponding numbers of research fellows and graduate students. Its research interests range from pure mathematics to astronomy. For purposes of research administration and graduate student training, the School is organised into a Mathematics Research Centre (MRC) and an Astronomy Unit (AU). The Computer Algebra Research Group falls under the auspices of the MRC although two members have strong links with the AU, providing a stimulating research environment whose work has close contacts with that of the Training Site. In the last national Research Assessment Exercise, the School achieved grade 5 in Pure Mathematics, Applied Mathematics and Statistics, placing it in the best 6 Mathematics departments in the UK.

### **2. Presentation of the Training Site**

The staff members to be put forward under this application include researchers from both Pure and Applied Mathematics. There are 5 full-time permanent staff – two Professors, two Readers and a Senior Lecturer – who are listed below. These would be primarily responsible for the supervision of fellows. There are also currently three PhD students. The group has its share of the support provided by the School's four administrative staff and two computing staff (the latter being supplemented by one part-time member of staff). The College's central administrative and computing staff provide additional support.

The group's interests interact at many points, and cohesiveness is maintained by regular weekly discussion sessions and seminars in which the fellows would participate. A great deal of mathematical discussion also takes place in the School Common Room, which has specially designed tables with white-board surfaces and a supply of dry-wipe pens.

### 3. Description of the Research Quality

The current research activities cover areas ranging from pure mathematics to computer science and include differential equations, group theory, graph theory, design theory and finite geometry, user interfaces and communications protocols. Implementation activities involve high level languages (REDUCE, Maple, GAP, MAGMA) and lower level languages (C, Lisp), and peripherally involve HTML, MathML, T<sub>E</sub>X, Perl, etc. There is considerable involvement with other members of the School who are users rather than developers of computer algebra systems.

We are the UK co-ordinating site for the ESPRIT programme CATHODE (Computer Algebra Tools for Handling Ordinary Differential Equations – Working Group No. 24490, URL <http://www-lmc.imag.fr/CATHODE2/>). This involves collaboration with the University of Kent in the UK, and with groups in France, Germany, Belgium, the Netherlands, Spain and Switzerland. REDUCE development involves collaboration with the Universities of Bath and Cambridge in the UK, and with developers principally in the US and Germany, but also elsewhere. GAP development involves collaboration with the University of St. Andrews in the UK, and MAGMA development involves collaboration with the University of Sydney, Australia. Members of the group have spent sabbatical leave in Canada, Brazil, Germany and Australia, and our computer algebra packages for investigating differential equations are applied to mathematical and physical problems in cooperation with groups in Leeds, Moscow and Vancouver.

Detailed profiles follow of researchers who will supervise fellows, and recent relevant publications are listed below.

**Prof. C. R. Leedham-Green:** Computational Group Theory. We have close contacts with the MAGMA and GAP projects. We have an active interest in almost all aspects of computational group theory; in particular with developing algorithms for computing with matrix groups over finite fields, and with nilpotent and soluble groups.

**Prof. M. A. H. MacCallum:** Computer algebra work is mainly on differential equations and tensor manipulators (especially SHEEP) for use in differential geometry and relativity. Section Editor, Journal of Symbolic Computation. General Chair, International Symposium on Symbolic and Algebraic Computation, 1994. Member, London Mathematical Society Council and Women in Mathematics Committee. For publications, which include books, an encyclopaedia article and original papers on computer algebra, see <http://www.maths.qmw.ac.uk/~mm>. Has supervised 23 PhD students (5 jointly); 17 have graduated, 11 hold posts in higher education and 5 are still in progress.

**Dr L. Soicher:** The interactions of computational group theory, graph theory, design theory and finite geometry. The design of algorithms and software for computing with groups, graphs, designs and finite geometries, resulting in the GRAPE share package for GAP4, and applications of this software to mathematical problems.

Has given instructional courses in algebraic and combinatorial computing in Ghent, Rome and the EIDMA institute in Eindhoven. Two book chapters (see below) have resulted (in part) from the EIDMA lectures. He is the QMW Mathematics SOCRATES co-ordinator, and was in charge of the QMW site for the European Union HCM project in “Computational Group Theory”, 1994–1996.

**Dr T. Wolf:** Work on computer algebra and differential equations (algorithms + implementations + applications); applications in General Relativity include exact solutions and their symmetry analysis. For publications see <http://www.maths.qmw.ac.uk/~tw>. Currently supervising two PhD students. German national.

**Dr F. J. Wright:** REDUCE development, in particular the ODE solver and simplification of formal derivatives and integrals; applications of Maple in teaching and in the Statistical Design of Experiments; web-based mathematics, in particular demonstrations of differential equation solvers; for details see <http://www.maths.qmw.ac.uk/~fjw>. Has supervised four PhD students, all of whom have graduated. Editorial Board Member of “The International Journal of Computer Algebra in Mathematics Education”. Open University MSc Course Consultant (for Maple). Former Alexander von Humboldt Research Fellow and Visiting Professor at the University of Tübingen, Germany.

#### 4. Description of the Research Facilities

The School (and the group) are well provided with computing resources and due to the long service of Profs. Leedham-Green, MacCallum and others, the College library is well provided with appropriate research journals and books. Funds are available for visiting seminar speakers and short-term visitors, and for travel and conference attendance by group members. Students normally share office space, which helps promote interaction between them. Each graduate student is assigned to a supervisor among the permanent staff, who will provide weekly research supervision.

Graduate students have full Internet access, including access to a number of electronic journals. As described above, we run the latest development versions of the computer algebra systems that we are involved in developing, for which we also have full source code.

#### 5. Evidence of Past International Postgraduate Training Success

The PhD students currently being supervised within the group are: Ruth Schwingel, German/Brazilian, about to submit her dissertation; Arrigo Triulzi, Italian, in the process of writing his dissertation; and Kulabalasingham Sudhakar, Sri Lankan, just beginning his second year.

Over the past five years, members of the group have supervised a number of international graduate students and researchers from Belgium, the Netherlands, Italy and Russia. Four German doctoral students in computational algebra and number theory have come to QMW to work with us for significant periods. We have supervised 4 overseas doctoral students (that is, working for overseas degrees), three in computation. Three students from Brazil and one from Hong Kong have graduated with PhD degrees from QMW and one student from Iran studied with the group. Many of these students published papers during their time at QMW, among whom G. Klaas, Y-K. Man and M. Mohammadzadeh appear below as co-authors.

We have also supervised a number of international students studying for the London Intercollegiate MSc in Mathematics who have graduated during the past 5 years. Arrigo Triulzi graduated from our MSc in Mathematical Computation programme before returning to us as a PhD student. (Kulabalasingham Sudhakar was our top graduate in Mathematics before continuing with us as a PhD student.)

### **Recent Relevant Publications**

- G. Klaas, C. R. Leedham-Green and W. Plesken: **Linear Pro- $p$ -Groups of Finite Width**, *Lecture Notes in Mathematics* **1674**, Springer, Berlin, (1997). viii+115 pp.
- C. R. Leedham-Green and E. A. O'Brien: **Tensor products are projective geometries**, *J. Algebra* **189** (1997), 514–528.
- C. R. Leedham-Green and E. A. O'Brien: **Recognising tensor products of matrix groups**, *International J. Algebra and Computation* **7** (1997), 541–559.
- M. A. H. MacCallum and F. J. Wright: *Algebraic Computing with REDUCE*. Oxford University Press, 1991, 300pp.
- Y-K. Man and M. A. H. MacCallum: **A rational approach to the Prellé-Singer algorithm**, *J. Symb. Comp.* **24**, 31–43 (1997)
- M. A. H. MacCallum: **Solving differential equations by computer algebra**  
In E. Hubbers, editor, *Differential and Difference Equations and computer algebra: in honour of A.H.M. Levelt*. University of Nijmegen, Nijmegen (1997)
- M. A. H. MacCallum: **Symbolic and algebraic computation**. To appear in the *Encyclopaedia of Computer Science and Technology*, ed. A. Kent and J.G. Williams, Marcel Dekker, New York. Available at <http://www.maths.qmw.ac.uk/~mm/tex/encycl.tex>
- L. H. Soicher: **The GRAPE 4.0 share package for GAP4**, including printed and on-line manual, 1999.  
Available at <http://www-gap.dcs.st-and.ac.uk/~gap/Share/grape.html>
- C. R. Leedham-Green and L. H. Soicher: **Symbolic collection using Deep Thought**, *London Math. Soc. J. Comput. Math.* **1** (1998), 9–24.
- L. H. Soicher: **On the structure and classification of SOMAs: generalizations of mutually orthogonal Latin squares**, *Electronic J. Combinatorics* **6** (1999), #R32. 15 pp., available at <http://www.combinatorics.org>
- H. Cuypers, L. H. Soicher and H. Sterk: **Working with finite groups**, in *Some Tapas of Computer Algebra* (A. M. Cohen, H. Cuypers and H. Sterk, eds), Springer, Berlin and New York (1999), 184–207.
- H. Cuypers, L. H. Soicher and H. Sterk: **The small Mathieu groups (Project)**, in *Some Tapas of Computer Algebra* (A. M. Cohen, H. Cuypers and H. Sterk, eds), Springer, Berlin and New York (1999), 323–337.
- S. Rees and L. H. Soicher: **An algorithmic approach to fundamental groups and covers of combinatorial cell complexes**, *J. Symbolic Comp.*, to appear.
- T. Wolf, A. Brand, M. Mohammadzadeh: **Computer algebra algorithms and routines for the computation of conservation laws and fixing of gauge in differential expressions**, *J. Symb. Comp.*, **27** (1999), 221–238.

- T. Wolf: **A study of Genetic Algorithms solving a Combinatorial Puzzle**. preprint (1997), 21 pages. Available as <ftp://ftp.maths.qmw.ac.uk/pub/tw/papers/puzzle.ps>
- T. Wolf: **Investigating differential equations with Crack, LiePDE, ApplySym and ConLaw**, to appear in *Handbook of Computer Algebra, Foundations, Applications, Systems*, Editors: J. Grabmeier, E. Kaltofen, V. Weispfenning, Springer Verlag. (This includes the software + html description to be put on a CD included in the book.)  
Available as <ftp://ftp.maths.qmw.ac.uk/pub/tw/papers/HCA1.ps>
- T. Wolf: **The computation of conservation laws for geodesic motion in curved spaces and for arbitrary PDE systems**, preprint (1998), 4 pages, to appear in *Handbook of Computer Algebra, Foundations, Applications, Systems*, Editors: J. Grabmeier, E. Kaltofen, V. Weispfenning, Springer Verlag.  
Available as <ftp://ftp.maths.qmw.ac.uk/pub/tw/papers/HCA2.ps>
- V.V. Sokolov, T. Wolf: **A symmetry test for quasilinear coupled systems**, *Inverse Problems* **15** (1998), L5–L11.
- T. Wolf: **Structural equations for Killing tensors of arbitrary rank**, *Comp. Phys. Comm.*, **115** (1998), 316 – 329.
- T. Wolf: **A comparison of four approaches to the calculation of conservation laws**, preprint, 23 pages (1998).  
Available as <ftp://ftp.maths.qmw.ac.uk/pub/tw/papers/conma.ps>
- T. Wolf: **A linearization of PDEs based on conservation laws**, preprint, 20 pages (1999). Available as <ftp://ftp.maths.qmw.ac.uk/pub/tw/papers/lin.ps>
- T. Wolf: **Size reduction and partial decoupling of systems of equations**, preprint, 12 pages (1999). Available as <ftp://ftp.maths.qmw.ac.uk/pub/tw/papers/short.ps>
- Y-K. Man and F. J. Wright: **Fast Polynomial Dispersion Computation and its Application to Indefinite Summation**. *Proc. ISSAC'94*, ACM Press (1994), 175–180.
- F. J. Wright: **An Enhanced ODE Solver for REDUCE**. *Programmirovanie* No 3 (1997), 5–22, in Russian, and *Programming and Computer Software* No 3 (1997), in English.
- F. J. Wright: **Design and Implementation of ODESolve 1+ : An Enhanced REDUCE ODE Solver and Design and Implementation of Web-Based Software Demonstrations**, *CATHODE Workshop presentations, Marseilles, May 1999*, available via <http://www.maths.qmw.ac.uk/~fjw/#CATHODE>