University of Birmingham

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About

Richard Kaye is Senior Lecturer in Pure Mathematics, specialising in Mathematical Logic.

His main interests are in Nonstandard Models of Arithmetic and other areas of Nonstandard Mathematics. He is the author of "Models of Peano Arithmetic" (OUP 1991) and "The Mathematics of Logic" (CUP 2007).

Richard is also well-known for his work on Minesweeper, showing that it can be used to encode problems of very high complexity ("Minesweeper is NP-complete", Mathematical Intelligencer, 2000) and this work was publicised in the Scientific American, and on the radio and in the national press both in the UK and in the USA.

Richard is an academic descendant of Alan Turing and has an Erdos number of three in two different ways.

Qualifications

- PhD (Manchester) 1987

Biography

Richard Kaye studied for PhD under Jeff Paris in Manchester. He did postdoctoral work as Junior Research Fellow in Oxford from 1987 to 1994. He joined the School of Mathematics at Birmingham University in 1994.

His research has always been centred on the topic of Nonstandard Models - systems of numbers behaving like normal numbers but which include infinite and infinitesimal. Study of these models is often combined with other disciplines, including complexity theory, recursion theory, set theory, algebra and analysis.

His teaching in Birmingham has ranged widely from his main interests in logic and computability theory to include most other areas of pure mathematics. He is the author of two monographs as well as co-author of a textbook on linear algebra. He is always enthusiastic in his teaching and is noted by students for some of the more unusual ways he sometimes employs to get a point across.

He has successfully supervised a number of PhD students in areas of Nonstandard models. As well as his research and teaching Richard has been engaged in administration of the School, including being Admissions Tutor and First Year Director. He is currently the School's Head of Quality Assurance and Enhancement.

Teaching

- Logic (MSM3P17 and MSM4P17)

Postgraduate supervision

- Nonstandard models of Peano Arithmetic: their structural and combinatorial properties, initial segments.
- Recursively saturated models of arithmetic and of other theories.
- Applications of nonstandard models to other areas of mathematics, especially algebra and group theory.
- Satisfaction classes and truth definitions over a nonstandard model of arithmetic.

Research

RESEARCH THEMES
Nonstandard models of Peano Arithmetic. Recursively saturated models of arithmetic and of other theories. Applications of nonstandard models to other areas of mathematics, especially algebra and group theory. Combinatorial game theory and nonstandard models. Satisfaction classes and notions of truth over a nonstandard model of arithmetic.

RESEARCH ACTIVITY
Structural properties of models of Peano arithmetic, and in particular their initial segments.

Richard Kaye is one of the main workers in the area of models of first-order arithmetic. There are a number of themes to this research, but most structural information about models of arithmetic relates to the order structure of the model. Richard's work includes linking this order structure to the automorphism group of models of PA, and

to looking at new families of initial segments, such as generic cuts. In many cases the structural properties are best understood through a language expanding that of PA by adding other predicates and functions - one representing the cut in question for example. This leads to new ways of looking at second order theories of arithmetic (utilising coding devices for example). The recent and on-going work with TL Wong, a PhD student of Richard's at Birmingham illustrates these ideas very well.

Strengthenings of the notion of recursive saturation and resplendency, in particular arithmetical saturation and transplendency.

Recursive saturation is a very natural and useful property that many nonstandard models of arithmetic have. In some cases (e.g. when the model has a nonstandard truth definition) recursive saturation is available "for free". Recursive saturation is closely related to the idea of resplendence in second order model theory. However, recursive saturation alone is often not enough for some results. An older result by Kotlarski, Kossak and Kaye shows that a countable recursively saturated model of PA has an automorphism moving every nondefinable point if and only if the model satisfies the stronger property of being arithmetically saturated. In recent work Kaye and his PhD student Engstrom looked at a powerful extension of this to form expansions of the model simultaneously omitting a type. The resulting notion - transplendency - is very powerful and not as yet fully understood and is still the subject of current research.

Properties of nonstandard algebraic structures, in particular nonstandard finite symmetric groups, abelian groups and linear groups.

Algebra and logic combine very well. Kaye has instigated a study of finite algebraic objects inside nonstandard models. This leads to some very attractive algebraic objects, including nonstandard symmetric groups (studied for example by Kaye and his research student Allsup) and nonstandard finite linear groups. Even nonstandard cyclic groups have interesting structure which is being investigated currently by another PhD student, Reading. Results in these areas show that symmetric groups are closely connected with so-called sofic groups, and nonstandard groups often have natural quotients with analytic structure and often with interesting measures. The work results in interesting new examples of algebraic objects with new means of reasoning about them. Nonstandard methods of this type can be applied to other areas too. Another PhD student of Kaye's is currently investigating Conway-style Combinatorial Games and the sorts of nonstandard games that arise from model theoretic considerations applied to these.

Other activities

- Mathematical Typesetting and MathML
- Philosophy of Mathematics

Publications

Selected publications:

Books

Kaye, R. (2007), The Mathematics of Logic: A guide to completeness theorems and their applications. Cambridge: Cambridge University Press.

Kaye, R. and Wilson, R. (1998) Linear Algebra. Oxford: Oxford University Press.

Kaye, R. (1991), Models of Peano arithmetic. Oxford: Oxford University Press.

Papers

Kaye, R. and Wong, T.L. (2010), Truth in generic cuts, Annals of Pure and Applied Logic, 161:987–1005.

Kaye, R. (2008) Generic cuts in models of arithmetic, Mathematical Logic Quarterly, 54:129-44.

Kaye, R. and Wong, T.L. (2007), On interpretations of arithmetic and set theory, Notre Dame J. Formal Logic, 48:497-510.

Allsup, J. and Kaye, R. (2007) Normal subgroups of nonstandard symmetric and alternating groups, Archive for Mathematical Logic, 46:107–121.

Kaye, R. (2000) Minesweeper is NP-complete, Mathematical Intelligencer, 22:9-15.

Kotlarski, H. and Kaye, R. (1994) Automorphisms of models of true arithmetic: recognizing some basic open subgroups, Notre Dame J. Formal Logic, 35:1-14.

Kaye, R. (1991) Hilbert's tenth problem for weak theories of arithmetic, Annals of Pure and Applied Logic, 61:63-74.

Kaye, R., Kossak, R. and Kotlarski, H. (1991) Automorphisms of recursively saturated models of arithmetic, Annals of Pure and Applied Logic, 55:67-99.

Kaye, R. (1990) Diophantine induction, Annals of Pure and Applied Logic, 46:1-40.

Kaye, R., Paris, J., and Dimitracopoulos, C. (1988), On parameter free induction schemas, The Journal of Symbolic Logic, 53:1082--97.