

Solutions of differential equations

The main focus of my research is on finding solutions to differential equations (ordinary and partial). A variety of techniques are used including group analysis (symmetry methods), singularity analysis and dynamical systems analysis. Part of my research focuses on research into these techniques themselves, while other aspects deal with applications of the techniques.

A current area of research into the techniques themselves deals with the concept of “Hidden Symmetries”. These are symmetries that arise unexpectedly in finding solutions to differential equations. We are currently involved in understanding exactly why these symmetries arise and whether one can determine, *a priori*, that they will arise for a given differential equation.

Another research project is concerned with symmetries of difference equations. This is a relatively recent area of research and a number of outstanding problems remain in the field. We are currently working on developing methods to find conservation laws for such equations using the symmetry properties of the equations themselves. In terms of applications, there are two main areas of research in which I am involved. The first is that of Relativity. A number of ordinary and partial differential equations arise in Cosmology and Relativistic Astrophysics. This is a fertile area to apply various techniques of solving differential equation.

The other area of application is Mathematical Biology. In this area we use a combination of symmetry methods and dynamical systems analysis to determine how various infectious diseases evolve. An interesting problem here is to look at the inclusion of synchronisation into the current models as a way to get a handle on human behaviour. We are also looking at different signalling pathways involved in the growth of cancer cells and the interaction with different growth factors. Finally, we are investigating the possibility of group theory underlying allometric scaling theory. There are opportunities for MSc and PhD students in all these areas of research.

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