Recent Advances in Mathematical Relativity

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1 Goal of the Research In Teams week

The three co-organizers met at BIRS in August 2007 to commence work on a review of the most significant recent advances in the mathematical understanding of Einstein's theory of gravitation. The aim of this work was to produce an article for publication in the Bulletin of the American Mathematical Society, which would be accessible to a broad audience within the mathematical community, and which would highlight both the major breakthroughs which have recently been made, as well as the challenging open problems which remain.

2 Progression and use of facilities

At the start of the meeting we made decisions over the basic areas which we would focus on in the article. We decided to begin with a concise introduction to Lorentzian geometry and causal theory and then have significant sections on black holes, the Cauchy problem, initial data sets, global evolution and marginally trapped surfaces. Our time at BIRS was divided between group meetings where we discussed the topics to be included, individual time spent actually writing different sections, and again group meetings where we critiqued each others progress and worked together on detailed parts of the manuscript. The combination of excellent facilities where we could work both individually and as a group, and the very pleasant surroundings of the Banff Center, were crucial to the success of the weeks work. Informal, relaxed time was spent by the group during meals at the wonderful dining hall and over a couple of hikes in the area where progress on the project was also made in more ethereal ways.

3 Scientific Progress Made

Over the course of the week we made substantial progress on the manuscript. We completed rough drafts of the sections on Lorentzian geometry and causal theory, black holes, the Cauchy problem and initial data sets. We left BIRS with over 70 pages of TeXed manuscript. Given the difficulty in completing such a piece of work with three co-authors widely separated geographically, having a large block of time to work exclusively on this at BIRS was crucial to the eventual success of the project.

Over the subsequent year additional work was done on the manuscript individually by each of the co-authors, and during visits by Galloway to Oxford University, and by Chruściel and Pollack to the University of Miami. The final work on the manuscript was completed at the Institut Mittag-Leffler, in Djursholm, Sweden in Autumn 2008.

4   Outcome of the Meeting

The paper *Mathematical General Relativity: A Sampler* [1] has been completed and submitted to Bulletin of the American Mathematical Society. It will appear shortly as an official preprint in the Mittag-Leffler Preprint series. It is an 84 page document with 328 references which gives an up-to-date snapshot of the state of the art in the field of mathematical relativity. Included in this work is a list of 20 significant open problems which are discussed within the text and summarized at the end. We hope that this work will serve to draw new researchers into the field and raise the awareness within the general mathematical community of this fascinating area, with its unique confluence of analysis, geometry and physics

A copy of the preprint is being sent together with this report.

References

[1] P.T. Chruściel, G. Galloway and D. Pollack, *Mathematical General Relativity: A Sampler*, 1–84, Submitted for Publication to the Bulletin of the American Mathematical Society, October, 2008.