MODELLING GRAVITATING DYONS, DYONIC MONOPOLE-ANTIMONOPOLE SYSTEMS AND BLACK HOLES

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In the early Universe matter and radiation are described within Grand Unified Theories (GUTs). These GUTs predict die existence of particles which carry magnetic charge and possess a very big mass: magnetic monopoles. In order to take into account the effects of gravity for these objects, they must be described within Einstein's General Relativity. General Relativity, on the other hand, makes itself a very important prediction: the existence of black holes.

Gravitating monopoles and related objects have been a very active field of research in recent years, leading to many interesting and unexpected phenomena. Most surprising was the existence of black holes in 3+1 dimensions, which are not uniquely determined by their mass, their charge, and their angular momentum. Therefore they are said ``to possess hair".

Whereas magnetic monopoles with unit magnetic charge are spherically symmetric, magnetic monopoles with 2 units of magnetic charge are only axially symmetric. For higher magnetic charge axially symmetric monopole solutions exist as well. However, besides these rotationally symmetric solutions also magnetic monopole solutions with only discrete symmetries appear. These symmetries can, for instance, correspond to the symmetries of the platonic solids. A major aim of this project has been the construction of gravitating monopoles with only discrete symmetries and their black hole counterparts: platonic black holes.

Monopoles and antimonopoles can form an equilibrium configuration, a monopole-antimonopole pair. If one inserts a black hole in between the pair, one obtains a black hole with dipole hair. Most interesting is, however, the question, whether it is possible to have a system of two black holes, one within the monopole and the other within the antimonopole, in equilibrium such that no singularity between the black holes would be needed to hold the two black holes apart. So far no such solutions of the Einstein equations are known.

The presence of electric charge gives rise to further new phenomena for these interesting solutions and influences the delicate balance of forces, allowing for such complicated equilibrium configurations. In particular, when electric charge is added to the solutions they cannot remain static. Instead they become stationary. Intriguingly, solutions with vanishing magnetic charge turn into rotating solutions with quantized angular momentum, where the angular momentum turns out to be proportional to the electric charge. Solutions with finite magnetic charge, on the other hand, cannot rotate. Their angular momentum vanishes. By studying such systems in detail, we are trying to obtain a deeper understanding of the physical principles behind these observations.

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