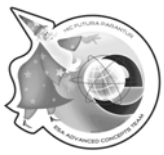
Executive Summary

Non-Perturbative Effects in Complex Gravitationally Bound Systems (study 07/1301)



Available on the ACT website
http://www.esa.int/act

Theme:
Fundamental Physics

Code and Title of the study:
07/1301 Non-Perturbative Effects in Complex Gravitationally Bound Systems

Contract characteristics :
University/Department: Vienna University of Technology, Institute of Theoretical Physics
ACT researcher: Luzi Bergamin
Duration of the study: 4 months

Picture:

Methodology:
Though general relativity is accepted today as the correct theory to describe the dynamics of our universe on large scales, there remain observational facts which seem to contradict the theoretical predictions of this theory. In the standard approach this problem is resolved by ad-hoc postulates such as dark matter or dark energy. Nevertheless, it has been proposed recently that at least parts of these discrepancies could be resolved within general relativity, if the full dynamics of this theory are taken into account instead of relying on standard approximation techniques. In this study one model of this type has been analysed in detail, its mathematical and physical problems have been worked out and new directions of research to resolve these issues have been formulated.

Results:
Despite some claims the result of this study does not support the point of view that dark matter can be fully understood as an effect of general relativity. Still, a considerable reduction may be possible (about 30 percent.)

However, this result was derived from a model which does not permit an outside observer and thus may apply for our own galaxy, but not for the observation of distant galaxies. An attempt go beyond this result led us to study the same question within the Meinel-Neugebauer disk of dust, where in its most naïve approach no large effects can be seen. Still, from this situation we were able to make a link to a recent result on dark energy, which suggest that not just the dynamics of the observed object, but also the dynamics of the observer should be taken into account. An estimate of this effect has been demonstrated in a simple toy model based on the Meinel-Neugebauer disk.

Publications:

Non-Newtonian behavior in weak field general relativity for extended rotating sources. H. Balasin and D. Grumiller, Int.J.Mod.Phys.D17:475-488,2008.

Highlights:

The astrophysical community at MIT took notice of our approach. The seminar talks by the Scientific Coordinator engendered a fruitful set of discussions with Bruno Coppi [MIT] and Paola Rebusco [MIT]. They are interested in the dynamics of accretion disks, and it turned out that our approach to set up an inverse problem, i.e., to treat the velocity profile as an input and to predict the mass density as an output, is useful also in other areas of gravitational physics, beyond the ones that we had envisaged in our project (for details see our project proposal and the scientific part of the final report). These contacts may well turn into a long-term collaboration, and the Scientific Coordinator was invited again to MIT for November/December 2008. As a consequence of these contacts, one of the astrophysics students at MIT, Ana-Maria Piso, is planning to perform a research project on these topics over the Summer 2009 at the host institution (Institute for Theoretical Physics, Vienna University of Technology).

The goals that we have formulated require a long-term approach, and it is fair to say that we are not completely there yet. However, despite of the relatively short time-span of our project we have achieved substantial progress on the pertinent questions. Above we have presented some of the formal outcomes of the project (papers, talks, conferences, collaborations, spin-offs, etc.). In the remainder of our final report we exhibit in detail the scientific impact of the ESA project *Non-perturbative Effects of Rotation in Gravitationally Bound Systems.*