John von Neumann Institute for Computing



Astrophysics

Peter L. Biermann

published in

NIC Symposium 2006 ,
G. Münster, D. Wolf, M. Kremer (Editors),
John von Neumann Institute for Computing, Jülich,
NIC Series, Vol. **32**, ISBN 3-00-017351-X, pp. 29-30, 2006.

© 2006 by John von Neumann Institute for Computing
Permission to make digital or hard copies of portions of this work for personal or classroom use is granted provided that the copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise requires prior specific permission by the publisher mentioned above.

http://www.fz-juelich.de/nic-series/volume32

Astrophysics

Peter L. Biermann

Max-Planck-Institute for Radioastronomy, 53010 Bonn, Germany
Department of Physics and Astronomy, University of Bonn, Germany
E-mail: plbiermann@mpifr-bonn.mpg.de

Today we know that the universe is full of dark energy, dark matter, a few percent in mass of ordinary matter, and a very small mass fraction in super-massive black holes. As the universe evolves, large scale structure is evolving, with ever larger scales, and ever more massive black holes at the centers of big galaxies. Although we do not even have any clue what dark energy is, and even wonder, whether the term itself might mislead us, we are beginning to try some ideas as to what dark matter is. Using the assumption, that dark matter interacts only gravitationally, and can be described as some unknown particle, with the help of supercomputers we can simulate the structure formation of the universe, and we can also try to understand how the black holes interact and grow. The interaction of black holes with stars may correspond to observable features at both the stellar mass scale, possibly related to Gamma Ray Bursts, as well as the super-massive mass scale, typically found in galactic nuclei. Nowadays we observe both Gamma Ray Bursts as well as Active Galactic Nuclei at redshifts beyond 6, so at a time, when the age of the universe was less than 1 billion years, while today our age is 13.7 billion years. Only with the large scale simulations can we hope to describe the universe, from the very large scale structure, all the way down to the early growth of black holes.

Large scale simulations of the universe

The radiation residuals of the Big Bang are still observable in the angular structure and the spectrum of the microwave background, predicted in the late 1940ies, and now observed. The WMAP project has finally given us in 2003 a good set of numbers that describe the universe in terms of dark energy (0.73 of critical density), dark matter (0.23), and baryonic matter (0.04). We do not understand dark energy, we surmise that dark matter is some unknown particle, and observationally we find only ten percent of the baryonic matter, certain to be there. And yet, the mathematical description is remarkably accurate, with residual errors in the range of typically 1 - 2 percent. Therefore, only large scale extensive simulations help us even ask all the right questions, of what we observe out there, like the missing dwarf galaxies. The work of Gottlöber et al. is an example of what can be done, and has to be done, going for the proper microphysics of the formation and evolution of dwarf galaxies to understand their scarcity in the real world.

Black holes

One aspect which is important here is the formation of the massive black holes at the centers of the biggest galaxies. They clearly form early in the universe, as observed, and

their early growth is a puzzle for some. How can one grow a black hole from a stellar size to 3 billion solar masses in much less than 1 billion years? Or do black holes of stellar size and super-massive scale form differently, say, from exploding super-massive stars? Or does dark matter enter here, by feeding the early black holes so very efficiently?

There are many indications that the physics of black holes at the various masses scales scale with mass, all the way from stellar mass to the super-massive scale, and if that is true, it is of very general merit to try to understand also the stellar explosions, which may lead to black holes, as Gamma Ray Bursts are generally believed to represent.

Also, as most super-massive black holes are rather quiescent most of the time, the occasional encounter with a star yields a great way to understand its physics. This may have been observed already, and so simulations such as done by Rosswog and Spurzem et al. allow us to study black hole physics in extreme situations.

Outlook

The next stage will certainly be on the one hand to test various models for what dark matter particles are - if particles are the correct starting point - and to include spin of the black holes in all such simulations. There is evidence that the spin of many black holes is near maximum, and that leads to many new effects, which may be observable; one such effect is the flip of the spin direction upon the merger of a super-massive black holes with another smaller black hole, whose orbital spin points in a very different direction. There are observations which strongly suggest such an interpretation. On the other hand, from particle physics we have a few clues now, that suggest that the growth of black holes, and the nature of dark matter may be related questions.

Only simulations on the structure formation in the universe, and including the effect of the birth, growth and influence of black holes, allow us to study these questions further.