

Preface

The last ten years have brought two fundamental advances in astrophysics: the discoveries of the accelerated expansion of the Universe with type Ia supernovae, as well as of the flatness of the Universe with the analysis of the angular fluctuations of the cosmic microwave background. Together, these two discoveries have allowed cosmologists to converge towards a concordance model, called Λ CDM, which is consistent with the internal kinematics of galaxy clusters and the cosmic gravitational shear.

However, the Λ CDM Universe is mainly built upon two entities of which we do not know the physical nature: dark matter and dark energy. Moreover, there seems to be significant discrepancies with several smaller-scale observations: in particular, in comparison to observational data, structures arising in very large N -body simulations of the Λ CDM Universe appear to be too cuspy in their centers and contain too many sub-structures.

In this context where ideas are rapidly evolving, we decided to bring together simulators, observation modelers and gravitational theorists, with the aim of mixing these three communities to converge in our understanding of the mass distribution in cosmic structures.

120 scientists gathered for the 21st IAP meeting, which was held at the Institut d'Astrophysique de Paris on July 4 to 9, 2005 on the subject of *Mass Profiles and Shapes of Cosmological Structures*, and organized jointly with the Observatoire de Paris.

We began with theoretical astrophysicists presenting explanations for the origins of the density profiles of cosmic structures, followed by numerical simulators showing us the latest from their cosmological (Λ CDM) and non-cosmological simulations, without and with gas (whose dissipative nature has important effects).

We then heard a large number of speakers discuss their models of the mass distributions in spiral (including the Milky Way), elliptical and dwarf spheroidal galaxies, as well as groups and clusters of galaxies. A variety of modeling techniques were used, from kinematical modeling of the velocity field or its moments, to X-ray analyses of the diffuse gas (with the XMM-Newton and Chandra satellites) thought to lie in hydrostatic equilibrium in the gravitational potential, to strong and weak gravitational lensing, and to promising joint analyses combining two of these techniques. Interestingly, the mass profiles produced by these analyses of observations are not always in accordance with the Λ CDM predictions, without or with gas.

Although the focus of the meeting was on mass profiles, we also heard about the intrinsic shapes of the mass distribution, as well as its clumpiness and expected caustics.

We continued with new techniques to map the matter, including direct detection (which would constitute an irrefutable proof of the existence of dark matter),

as well as indirect detection, through gamma ray emission from annihilating dark matter.

The meeting ended with an important session on modified gravitational interactions. New theoretical developments on the popular MOND theory and other ideas to modify the laws of gravity were presented. Emphasis was given on current (and future) observations that are (will be) difficult to explain with MOND.

Altogether, we felt that bringing together astronomers and physicists, observational modelers, numerical simulators and theoreticians made for a most exciting and stimulating meeting.

The meeting was also an excellent forum for the IAP to honor Dr. Sandra M. Faber with the IAP medal. Dr. Faber gave a very entertaining and thought provoking popular lecture on *The cosmic foundations of intelligent life*.

On a lighter note, all of us enjoyed the superb conference dinner at the glamorous *Le Train Bleu* restaurant.

This highly successful meeting would not have happened without the help of many people, in particular the members of the Local Organizing Committee: Delphine Charbonneau for her administrative work, Lionel Provost for help with the Web pages, Jean Mouette for help with the video, Delphine again for the conference poster and for the photos. We thank the IAP director, Laurent Vigroux, and IAP associate director, Martin Lemoine, for continuous moral support. We also gratefully acknowledge assistance from many of the IAP and Observatory students for help at the desk or with the microphones (Gwenaël Boué, Jean-Philippe Bruneton, Sara Caucci, Yohan Dubois, Liping Fu, Jean-Christophe Mauduit, Elisabeta Semboloni and Olivier Tiret).

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After understanding (better) the mass profiles and shapes of cosmological structures, it will be good to understand the origin of the minute density fluctuations of the primordial Universe that eventually led to these structures by gravitational instability. So, see you next summer in Paris at the 22nd IAP meeting, to discuss the *The First 25 Years of Inflationary Cosmology!*

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