

## Foreword

The CRAL-IPNL (Centre de Recherche Astrophysique de Lyon-Institut de Physique Nucléaire de Lyon) conference “Dark Energy, Dark Matter: Observations, Experiments and Theories”, was held at Université Lyon 1 in Lyon, France, from July 7th to July 11th 2008. It was the second conference in a series started in 2006 by CRAL with a meeting on chemodynamics.

The conference provided a stimulating forum for discussion of the latest results in the field of cosmology in general, and Dark Energy and Dark Matter in particular, two outstanding problems in contemporary physics. It was attended by over 120 participants from countries as diverse as Poland, South Africa, India, USA, representing all continents except Antarctica. A large number of students were among the participants. All talks were plenary, including seven invited reviews in addition to the opening review held by Brian Schmidt and the closing reflections by George F.R. Ellis.

The three Dark Energy reviews were presented by Subir Sarkar who opened a critical angle on the assumptions behind the standard model, Carlo Schimd who complemented the observational cosmology side of Subir’s talk, and Syksy Rasanen who explained how structure formation provides a potential candidate for Dark Energy. The four Dark Matter reviews began with Kathy Freese who surveyed the compelling astrophysical evidence for Dark Matter, while Pierre Salati described the candidates conjectured by particle physics to solve this riddle. Elena Aprile and Corinne Goy updated the progress being made by the very sensitive experiments searching for these elusive particles, directly and indirectly, respectively. Several posters completed the conference.

Doubtlessly, the major outstanding quests in current cosmological research are the explanation of Dark Energy and Dark Matter. Speaking in terms of cosmological models, both are problems that arise in the standard model of cosmology, *i.e.* if we assume that the Universe in the large is effectively modelled by a homogeneous-isotropic solution of Einstein’s laws of gravitation. Furthermore, there are a number of astrophysical results that call for the existence of Dark Matter.

The hunt for Dark Matter is entering an exciting phase as experiments are starting to check the predictions of supersymmetric particle models. Direct searches with a number of different technologies are preparing to scale up to several tens of kilograms, while indirect ones are yielding intriguing results. The LHC will also enter the fray for supersymmetry soon, and alternative theories for dark matter are being advanced.

We may put the wide spectrum of research directions pursued to resolve these problems into essentially three categories: the first assumes that the missing sources in Einstein’s equations are fundamental, *e.g.* one conjectures the existence of a repulsive cosmic fluid modeling Dark Energy and, furthermore, the existence of new weakly interacting massive Dark Matter particles providing challenges also for the standard model of particle physics. The second concludes that these dark components are an expression of the fact that the laws of gravitation have to be

modified, so that theories other than Einstein gravity are invoked that may give rise to an explanation of the dark components in terms of effective (geometrical) sources or modifications of the gravitational laws on the respective scales of the problems. Finally, the third aims at generalizing the model priors, while remaining within the framework of general relativity. Generalizations of the laws of gravitation including the multiverse proposal were critically addressed by George Ellis in his closing reflections.

In this conference we focussed on a number of observational results and ongoing astronomical projects and astrophysical experiments that support the existence of Dark Energy and Dark Matter. We tried to structure the presentation of astronomical and experimental data so that they can be confronted with model priors entering their interpretation. In this spirit we aimed at backing the observational and experimental sides of the problems with theoretical approaches that help to explain the physical properties explored. Astronomical observations were, thus, mainly exposed to the third of the above-mentioned research directions. This helped to concentrate on the observational issues addressed without, however, covering all possible paths of theoretical Dark Energy search. As for Dark Matter we also covered the first of the above-mentioned research directions of finding and constraining properties of fundamental Dark Matter particles.

The conference was a great success thanks to the enthusiasm of the participants and the high quality of their exposures. The Scientific Organizing Committee (Elena Aprile, Gabriel Chardin, George. F.R. Ellis, Kari Enqvist, Saul Perlmutter, Pierre Salati and Brian P. Schmidt) provided scientific guidance for the workshop. Pierre Salati also delivered a lively public outreach lecture on Dark Matter on the evening of July 9th. The Local Organizing Committee (Marie Berthier, Antoine Bouchard, Thomas Buchert, Yannick Copin, Philippe Di Stefano, Eric Emsellem, Jean-Francois Gonzales, chaired by Emmanuel Pécontal, and Emile Wernli) ensured that the conference ran smoothly. In particular, Marie Berthier (IPNL) contributed administrative support, and Emile Wernli (CRAL) designed the conference poster and organized the public outreach lecture. The Lyon town hall hosted a much-appreciated cocktail party, which included a guided tour of the historic city hall building. We are very grateful to Bruno Guiderdoni and Bernard Ille, respectively directors of CRAL and IPNL, for their support. The workshop was also made possible thanks to funding from the Scientific Council of Université Lyon 1.

The editors,  
T. Buchert (CRAL)  
Y. Copin (IPNL)  
Ph. Di Stefano (IPNL)  
E. Pécontal (CRAL)