**Strasbourg University - Strasbourg Astronomical Observatory**

**Doctoral school ED182 - October 2017**

***Inhomogeneous Cosmology and the Dark Universe***

Invited lecturer : Thomas Buchert, CRAL, Lyon

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The standard cosmological model is a successful fitting model to observational data. It leaves, however, in suspense an explanation of the physical origin of Dark Energy and Dark Matter. The contribution of the former converges to about 68% and that for the latter to about 27% of the sources of the standard cosmological equations, up to a few percent that have to be attributed to known sources such as baryonic matter, radiation and neutrinos.

There exist a large number of international projects that deal with the Dark Energy problem of standard cosmology. However, most of the efforts focus on (i) alternative theories of gravitation, or (ii) the study of phenomenological models for postulated new fundamental fields. Other large experiments are conducted worldwide to search for Dark Matter. Here again the solution of the Dark Matter problem is seen (i) either in the modification of the laws of gravitation, or (ii) in postulating the existence of new fundamental fields, therefore challenging current theories of particle physics. These broad lines of research are not only influencing theories, but are driving huge-scale particle physics experiments and astronomical observations. This demonstrates the exceptional relevance of a third research direction that has the potential to alter these activities fundamentally.

This course is based on this third new research direction, co–pioneered by the lecturer, that aims at understanding the dark sources on the basis of a more realistic description of the Universe, i.e. it remains within General Relativity, and it does not postulate new sources in the energy–momentum tensor. It challenges the priors of the standard model, for example the conjecture that the average properties of the Universe are well-described by a homogeneous solution (the standard model). The impact of inhomogeneities on average properties of the Universe is called “cosmological backreaction”.

The course will present in an elementary way the relevant notions in both Newtonian gravity and General Relativity. We shall need only a few aspects of these theories to derive cosmological models. We then look at average properties like the average expansion of the Universe and show that, without any restricting assumptions, we arrive at more general cosmological models. These models contain additional terms that can act as Dark Energy on large scales, but also as Dark Matter on smaller scales, thus unifying physically the “dark sector”. We shall study these additional “backreaction terms” and discuss important related questions.

Since a couple of years this research direction enjoys a strongly growing popularity. It has been the subject of special issues of leading journals in the field, and is regularly the object of conferences and workshops. Popularity is not only met at the level of the professionals but also in the broad audience

(see: http://www.galpac.net/projects/arthus/arthus\_en.html).   
and a summary of the research subject together with a recent interview with the lecturer (in french):

http://www.admiroutes.asso.fr/larevue/2016/172/buchert.htm

***Lecturer :*** Thomas Buchert is Professor of Cosmology at University Lyon 1 and holds an ERC Advanced Grant

on themes of inhomogeneous relativistic cosmology.

***Lecture Notes :*** Comprehensive Lecture Notes will be distributed to each participant.

***Main topics :*** Introductory remarks and slide show : Inhomogeneous Cosmology, Dark Universe

1. Integral Properties and Effective Dynamics in Newtonian Gravity

2. Integral Properties and Effective Dynamics in Einstein Gravity

***Time :*** 12 hours in 4 hour-sessions. **October 10th, 11th and 12th**, 2017, from 10 to 12am, and 2 to 4pm

***Place :***  Observatoire Astronomique, salle historique dite "salle de cours" du bâtiment principal

***Contact :*** T. Buchert, or for practical information : Mrs Leyla Ermis ([ermis@unistra.fr](mailto:ermis@unistra.fr)),

or Prof. Ariane Lançon, Observatoire astronomique de Strasbourg ([lancon@astro.unistra.fr](mailto:lancon@astro.unistra.fr))