ON THE VIABILITY OF THEORIES BEYOND EINSTEIN'S GENERAL RELATIVITY

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Overview

Einstein's theory of general relativity (GR) has proven successful over 100 years of experimental tests. These tests range from millimeter scale experiments in the laboratory to solar system and binary pulsars. It is therefore legitimately assumed GR as the theory to describe gravity on all scales. This assumption along with an additional matter component dubbed dark matter, a tiny cosmological constant and an inflation field became over the years the standard model in cosmology.

But Einstein's theory of GR has been required to defend its title as the true theory of gravitation since its birth. After the 100 years' anniversary of the theory, what is the status of the theory? Can we consistently modify it? As a matter of fact, even if our knowledge of the Universe grows over the years, it is still very poor and it is therefore premature to reject the other models. Indeed, the fact that $95\%$of the Universe have been unexpected observations, should trigger our skepticism. We know from history that unexpected observation of the advanced of the perihelion of Mercury has challenged many researchers of the 19th century. While Urbain Le Verrier postulated a new planet; Vulcan, to explain the observations. It turned out to be incorrect even if it was a simple and attractive idea. Einstein, by providing a new theory of gravity reached the correct solution. Therefore, we should keep in mind that unexpected observations might be a signature to a new theory.

Objectives

The primary objectives of the course are as follows:

i) To expose participants to the current knowledge about gravity by covering a large number of experiments and observations.
ii) Initiate the participants to the current problems in cosmology such as dark energy, the cosmological constant problem, dark matter and inflation.
iii) Introduce the general theory of Einstein and its current status as a theory to explain our Universe, and its extension following the fundamental principles of an effective theory.
iv) Introduction of screening mechanisms: chameleon and Vainshtein,
v) Applications of this formalism in the study of various models for each case with its successes and limitations.
vi) To provide training of Mathematica/Maple with applications to relativity and cosmology

Modules	**A: Duration : December03–08, 2017 (6 Days)** **B: Venue : Centre for Theoretical Physics** **Jamia Millia Islamia, New Delhi-25, India** ***Number of participants for the course will be limited to fifty.***
Who can Attend	▪ Researcher in General Relativity and Astrophysics. ▪ Graduate students with basic understanding of General Relativity.
Fees	The participation fees for taking the course is as follows: **Participants from abroad: US $500** **Industry/ Research Organizations: Rs. 30000/-** **Academic Institutions: Rs. 2000/-** ***The above fee includes all instructional materials, computer use for tutorials, 24 hr free internet facility. The participants will be provided with single bedded accommodation on payment basis.***

First Day: Sunday December 03, 2017

- Lecture 1: SGG 09.30-11.00
  - Modern Cosmology: Successes and limits.

- Lecture 2: RG 11.30-13.00
  - Dark energy models: Quintessence, Chaplygin gas.

- Tutorial: RG/SGG: 14.30-16.30
  - Method of calculation of the age of the universe and relation between redshift and cosmic time using Mathematica / Maple.

Second Day: Monday December 04, 2017

- Lecture 1: RG: 09.30-11.00
  - Laboratory, Solar system and astrophysical tests in the nearby universe.

- Lecture 2:RG: 11.30-13.00
  - Theory of perturbations and cosmological tests.

- Tutorial: SGG: 14.30-16.30
  - Mathematica / Maple Introduction as tools for basic statistics and method of χ^2 with confidence regions constraints.

ThirdDay: Tuesday December 05, 2017

- Lecture 1:RG: 09.30-11.00
    - Chameleon mechanism.

- Lecture 2: RG: 11.30-13.00
    - Application to models such as f(R) gravity.

- Tutorial: SGG/RG: 14.30-16.30
    - Study of background evolution through dynamical system analysis.

FourthDay: Wednesday December 06, 2017

- Lecture 1:RG: 09.30-11.00
    - Vainshtein mechanism

- Lecture 2: SGG: 11.30-13.00
    - Application to Galileon theory.

- Tutorial:RG: 14.30-16.30
    - Stability of the models by the calculation of gradient and tachyon instability conditionswith the ADM formalism using Mathematica in Lab.

Fifth Day: Thursday December 07, 2017

- Lecture 1:RG: 09.30-11.00
    - Testing modified gravity with astrophysical observations I: Pulsars.

- Lecture 2: SGG: 11.30-13.00
    - Modified gravity and Gravitational waves: Implications of the Binary Black-Hole Mergers

- Tutorial: RG: 14.30-16.30
    - Calculation of the matter power spectrum from the Standard Perturbation Theory + Lab.

Sixth Day: Friday December 08, 2017

- Lecture 1:RG: 09.30-11.00
    - Modified gravity and Gravitational waves/ Open problems in modified gravity- .

- Lecture 2: SGG: 11.30-13.00
    - Exam

- Afternoon: RG/SGG: 14.30-16.30
    - Evaluation and Marking

The Faculty

Prof.RadouaneGannoujiis a researcher in General Relativity and Theoretical Cosmology at the Pontifical Catholic University of Valparaiso (PUCV) in Chile (http://fis.ucv.cl/). He obtained his PhD atUniversity of Montpellier, France, in 2008, under the supervision of Professor David Polarski, followed by three postdoctoral fellowships in India, Japan and South Africa.His area of expertise is the study of extended theory of gravities and their viability through screening mechanisms, as well as their signatures from the largest scales to the laboratory. He has published more than 20 extensive articles in peer-reviewed journals (Journal of Cosmology and Astroparticle Physics, Physical Review D, Classical and Quantum Gravity, Physics Letters B) cumulating more than 1500 citations. He is a regular lecturer in Physics and Astronomy for undergraduate and graduate courses and is also a frequent reviewer in peer-reviewed journals and in research proposals in Chile, South Africa, France and Brazil.

Prof.Sushant G. Ghosh is a Professor at CTP, JamiaMilliaIslamia, Delhi with over 25 years of experience in Administration, Academic and Research. Presentably, He is Director (Research) of the University and also Director, Multidisciplinary Centre for Advanced Research and Studies, JamiaMilliaIslamia. He was formerly Associate Professor in the Dept. of Mathematics at BITS Pilani Dubai. His teaching and research focus on rotating black holes, general relativity, gravitational collapse and Astrophysics. He has published several research articles in peer-reviewed journals. He is also an Honorary Professor at School of Mathematical Sciences in University of Kwazulu-Natal, South Africa since 2012 beside being a Visiting Associate of Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune since July 2001. He is also a frequent reviewer in peer-reviewed journals and in research proposals in India and South Africa.

Course Co-ordinator

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Course Registration Link