Honours Thesis Presentations (3 talks)

DATE: Monday, March 21, 2016
TIME: Starting at1:15 PM
PLACE: C3024

1:15 PM: Deforming black hole and cosmological horizons

Anna O'Grady

ABSTRACT: We analyze the perturbed event horizons of black holes and cosmological solutions of Einstein's equations. This is done using the tools of differential geometry and ordinary differential equations. The technical difficulties behind the causal definition of a black hole - being an object from which even light can never escape - is explained and localized geometric definitions are substituted. These definitions allow us to locate the event horizons in three spacetimes: Schwarzschild, deSitter, and Schwarzschild-deSitter. These describe the spacetime geometry of a non-rotating non-charged black hole, of the expanding universe, and of a non-rotating non-charged black hole in an expanding universe, respectively. An open question is whether can deform the horizon surfaces to obtain new ones. We introduce small perturbations to the horizons and deduce constraints on the perturbations. We focus on axisymmetric perturbations, for which the constraints reduce to ordinary differential equations. The perturbations can be expressed in terms of Legendre functions that vary in their degree based on which spacetime is used. These are analyzed to test whether or not the various types of horizons allow perturbations on their surfaces. It is expected that black hole event horizons are unique and remain unperturbable, but the cosmological event horizons will admit some perturbations and still retain the geometric properties of a horizon.

1:35PM Geodesics Around Distorted Schwarzschild Black Holes

Cole Walsh

ABSTRACT: According to general relativity, mass curves spacetime in its vicinity. The trajectories along which all free particles fall are straight lines (geodesics) in this curved union of space and time. The simplest curved spacetime that is a solution of the vacuum Einstein equations is the Schwarzschild geometry describing the spacetime surrounding a spherically symmetric source of curvature. Here, we examine the geodesic motion of light rays (null geodesics) and massive particles (timelike geodesics) around a Schwarzschild black hole distorted by static and axisymmetric gravitational fields. We mainly restrict our attention to geodesics confined to the black hole's equatorial plane. Such geodesics generically exist if the spacetime has reflective symmetry across the equatorial plane (which corresponds to distortion fields free of odd multipole moments). We further specialize to the simplest, non-trivial distortion: that characterized by a quadrupole Weyl moment. By analysing the effective potential, we determine a range of quadrupole moments for which finite stable motion outside of the black hole is possible for timelike and null geodesics in the equatorial plane. Moreover, we show that the minimum innermost stable circular orbit (ISCO) for timelike geodesics is closer to the black hole horizon than that of an undistorted Schwarzschild black hole and that the distortion creates a null ISCO not present in the undistorted case.

1:55 PM: **Investigation of the Dynamics of Rod-like Colloidal Particles during Sedimentation**

Haruki Hirasawa

ABSTRACT: The dynamics of rod-like colloidal particles during sedimentation were studied using experiments performed using a laser scanning confocal microscope and simulations using Dissipative Particle Dynamics (DPD) and rigid body dynamics. We observe the clustering of the particles due to the Crowley effect in both experiments and simulations, and find that the colloids do not cluster as closely when they are allowed to rotate freely. Additionally, using DPD we simulated a number of simple systems to test the behaviour of the Crowley Instability at different Péclet numbers and observe that the Crowley instability stops appearing when Pe <100. This behaviour is consistent with definition of the non-Brownian domain of colloidal dynamics (Pe > 100).

ALL ARE WELCOME!