SYMPOSIUM ON GRAVITY AND LIGHT

30 September to 3 October 2013
Kavli IPMU (WPI), University of Tokyo, Kashiwa, Japan

PROGRAMME

Monday, 30th September

09.30-10.00: *Breakfast in the foyer (1st floor)*

Morning session. Chair: Frederic Schuller

10.00-11.00: Opening remarks and introductory talk,
Marcus Werner
(Kavli IPMU, University of Tokyo):
Applications of optical geometry to gravitational lensing
Abstract: Optical geometry (also called Fermat geometry) is the natural setting for spatial light rays. In this talk, I will review how Riemannian and Randers-Finsler optical geometries provide an interesting perspective on the topological property of image multiplicity in gravitational lensing, as well as on the deflection angle itself.

11.00-11.15: *Coffee break*

11.15-12.15: **Gary Gibbons**
(DAMTP, University of Cambridge, UK):
Gravitational optics
Abstract: I will review some recent developments in the mathematical theory of optics in gravitational fields.

12.15-14.00: *Lunch*

Afternoon session. Chair: Marcus Werner

14.00-15.00: **Erasmo Caponio**
(Politecnico di Bari, Italy):
Some applications of Finsler geometry to topological lensing
Abstract: Finsler geometry provides a convenient framework in which to study light propagation and causality of stationary spacetimes. In particular, the mathematical description of the topological lens effect can be reduced to counting geodesics between two points in a Randers space (which is a type of Finsler manifold). I will review some recent results about this point of view on topological lensing in connection with convexity of open subsets of a Finsler manifold.

15.00-15.30: *Coffee break, also IPMU teatime (3rd floor)*

15.30-16.30: **Masumi Kasai**
(Hirosaki University):
Does Λ bend light rays?
Abstract: It has been believed that the cosmological constant Λ does not contribute to the light deflection because there is no Λ in the second-order ordinary differential equation of photon. Recently, however, Rindler and Ishak pointed out that Λ does affect the bending angle. We re-examine the motion of photon in the Schwarzschild-de Sitter spacetime, and emphasize the following points: (a) Λ does appear in the orbital equation of light, (b) nevertheless the bending angle does not change its form even if Λ≠0 since the contribution of Λ is thoroughly absorbed into the definition of the impact parameter, and (c) the effect of Λ is completely involved in the angular diameter distance D_A.

Tuesday, 1st October

09.30-10.00: *Breakfast in the foyer (1st floor)*

Morning session. Chair: Shinji Mukohyama

10.00-11.00: **Misao Sasaki**
(Yukawa Institute for Theoretical Physics, Kyoto University):
Curvature perturbation in non-minimally coupled multi-field inflation models and its conformal frame dependence

11.00-11.15: *Coffee break*

11.15-12.15: **Frederic Schuller**
(University of Erlangen/ AEI, Germany):
Matter phenomenology dictates the underlying gravity theory
Abstract: Phenomenological models of matter require an underlying gravity theory to provide the coefficients of the matter field equations. Quite remarkably, the mere requirement of predictivity and quantizability of the matter dynamics already constrains the admissible coefficient fields so much that the Lagrangian for the gravitational dynamics can be shown to arise as the solution to a unique infinite system of homogeneous linear partial differential equations whose coefficients can be constructed directly from the coefficients of the given matter field dynamics. One comparatively easily checks that Einstein-Hilbert gravity directly arises by virtue of this mechanism from standard model matter. The same can and must be done in order to derive the classical gravity theory underlying any phenomenological matter model one wishes, or is observationally prompted, to consider.

12.15-14.00: *Lunch*

Afternoon session. Chair: Amir Aazami

14.00-15.00: **Jean-Philippe Uzan**
(CNRS/Institut d'Astrophysique & Institut Henri Poincaré, France):
Gravitational lensing as a probe of the physics and geometry of the universe
Abstract: Over the past 20 years, gravitational lensing has become a central tool of cosmology. I will describe early studies on the detectability of topological defects, the growing field of the tests of general relativity on astrophysical scales and the possibility to constrain the isotropy of the cosmic expansion. Each of these tests allows to probe our cosmological models and can be implemented by future surveys, such as the Euclid satellite.

15.00-15.30: *Coffee break, also IPMU teatime (3rd floor)*

15.30-16.30: **Takayoshi Ootsuka**
(Ochanomizu University):
Killing symmetry and hidden conserved quantity on Finsler manifold
Abstract: A Lagrange system can define a Finsler structure on the extended configuration space.This Finsler-Lagrange formulation has the feature of reparametrisation invariance (covariance) besides coordinate-free treatment and is suited to discuss and calculate physical problems. In this formulation, we can define the variational symmetry as Killing vector which preserves the Finsler metric.These Killing vectors express the symmetries of the Lagrange system and derive conserved quantities from the Noether's theorem. In this talk, we will present an alternative definition of the Killing vector using a non-linear connection that is defined in such way as to preserve the Finsler metric, and we will apply it to the planet motion and derive equations which define the Runge-Lenz vector.

Wednesday, 2nd October

09.30-10.00: *Breakfast in the foyer (1st floor)*

Morning session. Chair: Shinji Mukohyama

10.00-11.00: **Hideki Asada**
(Hirosaki University)**:**
Gravitational lensing by an exotic lens object with negative convergence
Abstract: Our Hirosaki gruop has recently studied gravitational lens models with negative convergence (surface mass density projected onto the lens plane) inspired by modified gravity theories, exotic matter and energy. In this meeting, I shall discuss exotic lensing properties such as possible demagnification of images and gravitational lensing shear. Main references are [Kitamura, Nakajima and Asada, PRD 87, 027501 (2013), Izumi et al. to be published in PRD (2013)].

11.00-11.15: *Symposium photograph, near Kavli IPMU entrance (1st floor), Coffee break*

11.15-12.15: **Kei-ichi Maeda**
(Waseda University):
Gravitational lensing and black hole shadow
Abstract: A black hole casts a shadow as an optical appearance because of its strong gravitational field. We study how to determine the spin parameter and the inclination angle by observing the apparent shape of the shadow, which is distorted mainly by those two parameters. Defining some observables characterizing the apparent shape (its radius and distortion parameter), we find that the spin parameter and inclination angle of a Kerr black hole can be determined by the observation. This technique is also extended to the case of a Kerr naked singularity.

12.15-14.00: *Lunch*

Afternoon session. Chair: Amir Aazami

14.00-15.00: **Tetsuya Shiromizu**
(Kyoto University):
Extreme trapping horizon
Abstract: Introducing the concept of the extreme trapping horizon, we discuss geometric features of dynamical extreme black holes in four dimensions and then derive the integral identities which hold for the dynamical extreme black holes. We address the causal/geometrical features too.

15.00-15.30: *Coffee break, also IPMU teatime (3rd floor)*

15.00-17.00: *Optional excursion:*
Hondo Temple in Matsudo (本土寺, 松戸市).
Please sign up at the registration desk by **Wednesday noon.**
Itinerary: by bus to Kashiwa station, by train (local Jōban/Chiyoda line) to Kitakogane (北小金). Entrance fee: 500 yen.

19.00-21.00: *Symposium banquet:*
Odayaka, near Kashiwa station, west exit (穏香: 柏西口店).
Please sign up at the registration desk on **Monday.**
Japanese cuisine, set course 3800 yen, partially covered.

Thursday, 3rd October

09.30-10.00: *Breakfast in the foyer (1st floor)*

Morning session. Chair: Frederic Schuller

10.00-11.00: **Volker Perlick**
(ZARM, University of Bremen, Germany):
On the shadows of black holes and of other compact objects
Abstract: For an observer at a radius r > 2m in the spacetime of a Schwarzschild black hole, light from sources at big radii leaves a circular disc in the sky dark which is called the 'shadow' of the black hole. The boundary of this shadow corresponds to past-oriented light rays that start at the observer's position and asymptotically spiral towards r = 3m. For a Kerr spacetime, the shadow is non-circular; the boundary corresponds to light rays that asymptotically spiral towards spherical light rays, i.e., light rays that stay on a sphere r = constant. After a review of these known results, analytic formulas are given for the shadow of more general objects, including black holes with electric and magnetic charge, NUT parameter and a cosmological constant. In addition to black holes, the case of an ultracompact star or of a naked singularity is also considered. Finally, the perspectives of observing the shadow of the black hole at the centre of our galaxy is discussed. -- This talk is partly based on preliminary results from the forthcoming PhD Thesis of Arne Grenzebach.

11.00-11.15: *Coffee break*

11.15-12.15: **Ricardo Gallego Torromé**
(Universidade Federal de Sao Carlos, São Paolo, Brazil):
On k-jet field approximations to geodesic deviation equations
Abstract: Let M be a smooth manifold and S a spray defined on an open convex cone C of the tangent bundle TM. In this talk we will discuss the possible non-trivial k-jet approximations to the exact geodesic deviation equation of S, linear on the deviation functions and invariant under arbitrary local coordinate transformations. If linearity in the deviation functions is not required, there are differential equations invariant under arbitrary coordinate transformations whose solutions admit k-jet approximations. As an example of higher order geodesic deviation equations we study the first and second order jet geodesic deviation equations for a Finsler spray. Implications in physics will be highlighted.

12.15-14.00: *Lunch*

Afternoon session. Chair: Marcus Werner

14.00-14.30: **Amir Aazami**
(Kavli IPMU, University of Tokyo):
Magnification invariants and the A,D,E family of caustic singularities
Abstract: We describe higher-order analogs of the well-known "fold" and "cusp" magnification relations in gravitational lensing. These are uncovered via a simple application of orbifolds, using a residue technique developed by Dalal & Rabin (2001).

14.30-15.00: **Zhe Chu**
(Shanghai Astronomical Observatory, China):
Magnification Relations of Singular Isothermal Quadrupole Lens and Perturbed by High-orders
Abstract: I'll talk about the Singular Isothermal Quadrupole (SIQ) lens system, which is the simplest lens model that can produce four images. The basic properties of the SIQ lens are studied, including deflection potential, deflection angle, magnification, critical curve, caustic, pseudo-caustic and transition locus. With this simple lens, we study the situations that a point source infinitely approaches a cusp or a fold. Unlike the traditional views, we find the sums of magnifications of cusp image triplet or the fold image pair are usually not equal to 0. Then, I'll talk about the caustics that are composed of two overlapping layers. When a point source traverses such overlapping caustics, the image numbers change by 4, rather than 2. We also focus on the magnification patterns of the quadrupole lenses perturbed by m=3, 4 and 5 modes, and found that one, two, and three butterfly or swallowtail singularities can be produced respectively. With the increasing intensity of the high-order perturbations, the singularities grow up to bring sixfold image regions. If these perturbations are large enough to let two or three of the butterflies or swallowtails contact, eightfold or tenfold image regions can be produced as well.

15.00-15.30: *Coffee break, also IPMU teatime (3rd floor)*

15.30-16.00: Concluding remarks,
Shinji Mukohyama
(Kavli IPMU, University of Tokyo)

16.00: *End of symposium*