Supermassive Black Hole and Fundamental Physics

Report of Contributions

https://indico.itp.ac.cn/e/SMBH

Contribution ID : **3** Type : **not specified**

Testing General Relativity with black hole X-ray data: a progress report

Sunday, 26 September 2021 10:45 (30)

The theory of General Relativity has successfully passed a large number of observational tests. The theory has been extensively tested in the weak-field regime with experiments in the Solar System and observations of binary pulsars. The past five years have seen significant advancements in the study of the strong-field regime, which can now be tested with gravitational waves, X-ray data, and mm Very Long Baseline Interferometry observations. In my talk, I will summarize the state-of-the-art of the tests of General Relativity with black hole X-ray data, discussing its recent progress and future developments.

Presenter(s) : BAMBI, Cosimo (Fudan University)

Contribution ID : **4** Type : **not specified**

Dark matter fluxes from Accreting Black Holes and Direct Detections

Sunday, 26 September 2021 11:15 (30)

We discuss the possibility that accreting black hole systems could be sources for dark matter flux through several different mechanisms. We firstly discuss two types of systems: coronal thermal plasmas around supermassive black holes in active galactic nuclei (AGNs), and accretion disks of stellar-mass X-ray black hole binaries (BHBs). We explore how these black hole systems may produce keV light dark matter fluxes and find that the dark fluxes from those sources might be too weak to account for the current XENON1T excess. On the other hand, black holes can be good accelerators to accrete and boost heavy dark matter particles. If considering collisions or dark electromagnetism, those particles could then escape and reach the benchmark speed of 0.1c at the detector. We also extend the black hole mass region to primordial black holes (PBHs) and discuss the possibility of contributing to keV light dark flux via superradiance of PBHs.

Presenter(s) : SUN, Sichun (Beijing institute of technology)

Contribution ID : **5** Type : **not specified**

Thermal Equilibrium of a charged star in electromagnetic fields and gravitational fields

Sunday, 26 September 2021 11:45 (30)

In this talk, I will revisit the condition for the thermal equilibrium of charged fluids in electromagnetic fields and gravitational fields, where the Tolman like law is derived by the maximal entropy principle from scratch. As a warm up, I will first address the case with the electromagnetic fields and gravitational fields fixed as background fields. After this, I will move onto the charged star by taking into account the backreaction of charged fluids onto the electromagnetic fields and gravitational fields through Maxwell equation and Einstein equation. Based on our result I will conclude my talk with an interesting perspective into the rotation curve.

Presenter(s) : ZHANG, Hongbao (Beijing Normal University)

Contribution ID : **7** Type : **not specified**

Shadow of the Supermassive Black Hole in M87: EHT observations and theoretical interpretation

Sunday, 26 September 2021 09:00 (60)

The Event Horizon Telescope has mapped the central compact radio source of the elliptical galaxy M87 at 1.3 mm with unprecedented angular resolution. These images show a prominent ring with a diameter of ~40 micro-arcsecond, consistent with the size and shape of the lensed photon orbit encircling the "shadow" of a supermassive black hole. Recently EHT has provided new images of the polarised emission around the central black hole in M87 on event-horizon scale. This polarised synchrotron emission probes the structure of magnetic fields and the plasma properties near the black hole. We found that the net azimuthal linear polarisation pattern may result from organised, poloidal magnetic field in the emission region. In a quantitative comparison with a large simulated polarimetric image library, we found that magnetically arrested accretion disks is favoured to explain polarimetric EHT observations. In this talk, I also discuss about the testing theory of gravity from the black hole shadow image by EHT and future ngEHT.

Presenter(s) : MIZUNO, Yosuke (Tsung-Dao Lee Institute, Shanghai Jiao-Tong University)

Contribution ID : **8** Type : **not specified**

Probing Ultralight Bosons with Compact Eccentric Binaries

Sunday, 26 September 2021 13:30 (30)

Ultralight bosons can be abundantly produced through superradiance process by a spinning black hole and form a bound state with hydrogen-like spectrum. We show that such a "gravitational atom" typically possesses anomalously large mass quadrupole and leads to significant orbital precession when it forms an eccentric binary with a second compact object. Dynamically formed black hole binaries or pulsar-black hole binaries are typically eccentric during their early inspirals. We show that the large orbital precession can generate distinct and observable signature in their gravitational wave or pulsar timing signals.

Presenter(s) : XIANYU, Zhong-Zhi (Tsinghua University)

Contribution ID : **9** Type : **not specified**

Dissecting Axion Around SMBH with EHT/ngEHT

Sunday, 26 September 2021 14:00 (30)

Ultralight bosons can potentially accumulate around these supermassive black holes and form a gravitational atom-like bound state. A new way to look for the gravitational atom made of axion is through birefringence effect from the axion-photon coupling.The presence of coherently oscillating axion leads to a frequency independent oscillation to the electric vector position angle (EVPA) of the linearly polarized radiation. One can also dissect the profile of the gravitational atom by correlating the spatial and temporal variation of the EVPAs.

Presenter(s) : CHEN, Yifan (ITP-CAS)

Contribution ID : **10** Type : **not specified**

Constraining the dark matter density profile and the fifth force with the orbits of stars in the Galactic Center

Sunday, 26 September 2021 14:30 (30)

A dense and luminous star cluster exists in the central parsecs of the Milky Way. S2 is one of the most interesting targets whose pericenter is about ~5x10^-3 pc from the supermassive black hole. Recently both the GRAVITY and Keck groups have published their observations on the S2 star around its closest approach, which provides us a good chance to probe the properties of dark matter (DM) around the Galactic center. In this presentation, we introduce our preliminary studies on two kinds of DM models using the orbital motions of S stars in the Galactic center. The first one is the density spike of a general DM scenario, and the other is the coupling between the standard model particles and the hypothetical bosonic DM.

Presenter(s) : SHEN, Zhao-Qiang (Purple Mountain Observatory)

Contribution ID : **11** Type : **not specified**

Correspondence of eikonal quasinormal modes and unstable fundamental photon orbits for Kerr-Newman black hole

Sunday, 26 September 2021 15:30 (30)

In this work, we study the relation of the eikonal quasinormal modes (EQNMs) and the unstable fundamental photon orbits (UFPOs) in the Kerr-Newman spacetime. We find that in the eikonal limit the gravitational and electromagnetic perturbations of the KerrNewman black hole are naturally decoupled, and a single one-dimensional Schr¨odinger-like equation encoding the QNM spectrum can be derived. We then show that the decoupled Teukolsky master equation and the Klein-Gordon equation for the massless scalar field in the Kerr-Newman spacetime are of the same form in the eikonal limit. As a direct consequence, taking into account of the boundary conditions for EQNMs we show an exact correspondence between EQNMs and UFPOs, that is, EQNM/UFPO correspondence. More precisely, similar to the Kerr case, the real part of EQNM's frequency is a linear combination of the precessional and (polar) orbital frequencies, while the imaginary part of the frequency is proportional to the Lyapunov exponent of the UFPO.

Presenter(s) : GUO, Minyong (Beijing Normal University)

Contribution ID : **12** Type : **not specified**

Neutrinos and gravitational waves from magnetized neutrino-dominated accretion discs with magnetic coupling

Sunday, 26 September 2021 10:00 (30)

Gamma-ray bursts (GRBs) might be powered by black hole (BH) hyperaccretion systems via the Blandford–Znajek (BZ) mechanism or neutrino annihilation from neutrino-dominated accretion flows (NDAFs). Magnetic coupling (MC) between the inner disc and BH can transfer angular momentum and energy from the fast-rotating BH to the disc. The neutrino luminosity and neutrino annihilation luminosity are both efficiently enhanced by the MC process. In this paper, we study the structure, luminosity, MeV neutrinos, and gravitational waves (GWs) of magnetized NDAFs (MNDAFs) under the assumption that both the BZ and MC mechanisms are present. The results indict that the BZ mechanism will compete with the neutrino annihilation luminosity to trigger jets under the different partitions of the two magnetic mechanisms. The typical neutrino luminosity and annihilation luminosity of MNDAFs are definitely higher than those of NDAFs. The typical peak energy of neutrino spectra of MNDAFs is higher than that of NDAFs, but similar to those of core-collapse supernovae. Moreover, if the MC process is dominant, then the GWs originating from the anisotropic neutrino emission will be stronger particularly for discs with high accretion rates.

Presenter(s) : SONG, Cui-Ying (TDLI, SJTU)

Contribution ID : **13** Type : **not specified**

Limits on WIMP Annihilation from the M87 EHT Observations

Sunday, 26 September 2021 16:00 (30)

The fast developments of radio astronomy open a new window to explore the properties of dark matter. In this talk, I will introduce our recent work on this topic, constraining WIMP annihilation from the Event Horizon Telescope obsevations of the M87 supermassive black hole. Assuming the existence of a spiky dark matter density profile, we derive the new limits on the WIMP annihilation cross section. Our results show that the annihilation cross section with several orders of magnitude below the thermal freeze-out production can be excluded by the EHT observations under the density spike assumption. Future EHT observations may provide a unique opportunity to test the interplay between dark matter and the supermassive black hole.

Presenter(s) : DING, Ran (Anhui University)

Contribution ID : **14** Type : **not specified**

Hunt for new physics beyond general relativity with the black hole photon ring

Sunday, 26 September 2021 16:30 (30)

The image of supermassive black hole taken by the Event Horizon Telescope has evolved the photon ring from a theoretical concept into a possible observable of black holes. I will first review the technological and theoretical advances that make photon ring detectable and explain why photon ring is unique on testing general relativity. Based on the fact that the establishment of the equivalence principle is a benchmark for general relativity, I will introduce the phenomenological behaviors of the photon ring in violation of the equivalence principle to make a connection between various of new physics beyond general relativity and the features of photon ring. I will conclude with some specific tests of new physics through the photon ring.

Presenter(s) : LI, Chunlong