中央大學物理學系

Department of Physics, National Central University

Colloquium

Extreme Astrophysics and Laboratory Astrophysics

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Abstract :

Astrophysical compact objects have strong gravity and some of them, such as highly magnetized neutrons and mergers of neutron stars, have also ultra-strong magnetic fields. Gravitational waves are a phenomenon of strong gravity, not to mention black hole physics. Strong electromagnetic fields of neutron stars or magnetized black holes will open another new window for strong field physics. Particularly, magnetars have magnetic fields stronger than the critical field (4.4x1013 G or 1029 W/cm2), whose lowest Landau level equals to the rest mass of electron (positron), and in which photon propagation undergoes vacuum birefringence with the wrench (magnetoelectric) effect. The current IXPE and the future X-ray polarimetry, such as e-XTP and Compton Telescope, will observe the new phenomena due to the vacuum polarization.

In this talk I will review the status of both theoretical and experimental strong field QED physics, address perspectives of the Einstein-Maxwell-QED theory in astrophysics, and advance laboratory astrophysics. Strong field QED drastically modifies the linear Maxwell theory to highly nonlinear electrodynamics of Heisenberg-Euler and Schwinger QED action in addition to the Maxwell action. Thus, the Dirac vacuum becomes a polarized medium due magnetoelectric response with the dielectric and permeability, and furthermore, strong electric fields produce pairs of charged particles and antiparticles, the so-called Schwinger effect. Though the current highest intensity is 1023 W/cm2 achieved by CoReLS-IBS, our galaxy abounds with astrophysical compact stars with near or supercritical fields.

Finally, I propose a laboratory astrophysics that simulates extreme environments of compact astrophysical objects, such as neutron stars and magnetized black holes. These compact objects have both ultra-strong EM fields and strong gravity. Extremely high intensity lasers under development or proposed will open windows for ultra-strong EM fields and for huge acceleration of charges. Then Einstein equivalence principle associates acceleration with a gravity that can be measured by the Unruh temperature. Hence the extremely high intensity lasers will be an arena for laboratory astrophysics, such as gamma-rays, Unruh effect (analog black hole), nonlinear Compton scattering etc.