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Neutron Stars as Strong Field QED Laboratory

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Strong electromagnetic fields polarize the vacuum and electric fields produce charged pairs, the so-called Schwinger effect. The critical strength of electromagnetic fields, whose energy density equals to the rest mass of the charge, cannot be achieved in present laboratories. The critical electric fields enormously produce electron-positron pairs and the critical magnetic field has the lowest Landau level whose energy equals the rest mass of the charge and gives a measurable effect on the photon propagation.
I will address the physics in strong electromagnetic fields of neutron stars and advance methods to observe the vacuum polarization effects. Magnetars, the highly magnetized neutron stars, have magnetic fields stronger than the critical field and lead to measurable vacuum polarization effects such as the birefringence. A super-critical magnetic field in the Goldreich-Julian pulsar model induces a subcritical electric fields due to high spinning of neutron star, and hence the wrench effect of both electric and magnetic fields becomes significant in the propagation of light modes. The vacuum birefringence will be formulated to include the wrench effect and the X-ray polarimetry will be studied which can be measured in the future space telescopes, such as IXPE, e-XTP and Compton Telescope.

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