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Hunting Axions Using Astrophysical Observation and Quantum Metrology

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Ultralight bosons behave like coherent waves when the occupation number is large enough. If they are coupled to the Standard Model sector of the particle physics, such an oscillating background can induce a tiny signal. Near a fast rotating black hole, axion within one order of the mass window can accumulate through superradiance, with a large density saturating the non-linear self-interaction. If linearly polarized radiation is emitted near the black hole, axion can contribute to birefringence effect that shifts the position angle periodically, making the polarimetric measurements of the Event Horizon Telescope a powerful way to look for ultra-light axions. On the other hand, quantum metrology can play huge roles in the measurements of fundamental physics. Among these, resonant detection of axion dark matter based on electromagnetic coupling is a popular direction attracting many ongoing experiments and proposals such as microwave cavity, LC circuit and superconducting radio-frequency cavity. A quantum network of resonators can strongly enhance the signal power and boost the search. A network of spin dependent sensors with long baseline can identity the microscopic nature of dark matter or other cosmological background and increase the spatial resolution for transient source like axion or dark photon wave as well.

Presenter: CHEN, Yifan (ITP-CAS)