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The Formation and Evolution of Supermassive Black Holes in the Early Universe

Abstract

Supermassive black holes (SMBHs) remain enigmatic cornerstones of cosmic evolution, with their origins and rapid growth presenting challenges to theoretical models. In this talk, I will explore the leading paradigms for SMBH formation and evolution, focusing on three primary seeding mechanisms: direct collapse black holes (DCBHs), remnants of Population III stars (PopIII seeds), and primordial black holes (PBHs). Each scenario offers unique insights into the initial conditions and physical processes shaping the high-redshift universe.

Recent observations from the James Webb Space Telescope (JWST) have revealed SMBH candidates at $z>10$, providing critical constraints on the early growth pathways. These observations challenge traditional timescales and demand re-evaluation of accretion efficiencies, merger histories, and feedback processes in nascent galaxies. Additionally, I will highlight how the forthcoming Advanced X-ray Imaging Satellite (AXIS) mission promises to complement JWST by probing the high-energy signatures of SMBHs, unveiling their accretion dynamics and environmental impact in unprecedented detail.

By integrating theoretical models with cutting-edge observational data, this talk aims to provide a comprehensive picture of the formation and evolution of SMBHs, addressing key questions about their role in cosmic structure formation and their implications for future surveys.