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Neoteric Information on Supermassive Black Holes

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Editorial

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EDITORIAL NOTE

The recent unprecedented discovery of extragalactic high-energy neutrinos has enabled pinpointing their source to blazars, which are supermassive black holes (SMBHs) at a distance of ~1.75 Gpc with relativistic jets directed almost exactly toward us. It is generally believed that such neutrinos are tracers of Ultrahigh-Energy Cosmic Rays (UHECRs). UHECRs are the foremost energetic among particles detected on Earth, with an energy E>1018 eV that's unreachable by the present most powerful particle accelerators, like the massive Hadron Collider with a maximum energy 1018 eV are extragalactic with very high confidence level. The spectrum of cosmic rays exhibits the presence of the so-called knee and ankle. Cosmic rays with energy up to ~1015.5 eV (knee) are generally believed to be produced in Galactic supernova explosions, while the many lowering of flux between the knee and 1018.5 eV (ankle) suggests a change within the source of such particles.

The flux of cosmic rays with energies >5 × 1019 eV is extremely low, which causes the most difficulty in unveiling their source and physics. So as to elucidate the very best energy cosmic rays, several exotic scenarios are proposed, including extra dimensions, violation of Lorentz invariance, and therefore the existence of latest, exotic particles. By analyzing the radio images of the blazar jets, Britzen suggested that high-energy neutrino can possibly be explained by the collision of two jets. Among the astrophysical acceleration mechanisms for UHECRs, relativistic shocks during plasma of relativistic jets are previously considered among the foremost plausible. However, the recent results and estimates may indicate that shock acceleration isn't ready to account for UHECR energies above 1020 eV. Therefore, the assembly and acceleration mechanisms of UHECRs remain unclear.

The overwhelming majority of galactic nuclei, if not all, are expected to host a central supermassive region (SMBH), often surrounded by a Nuclear Cluster (NC). Large masses and densities make NCs excellent factories for the assembly of stellar-mass black holes, which possibly pair in binaries (black hole binaries, BHBs) and infrequently merge, releasing Gravitational Waves (GWs). The mechanisms that favor BHB formation in galactic nuclei are still partly unknown. In NCs without a central SMBH, dynamical interactions represent one among the dominant processes for BHB buildup and merger, possibly contributing to the observed population of GW sources. The image becomes more complex if the galaxy hosts an SMBH, as this will affect BHB evolution in two ways. On the one hand, the high-velocity dispersions in these environments suppress low-velocity dynamical interactions, particularly three-body scattering, leaving little room within the space for BHBs to make . On the opposite hand, newly formed BHBs can undergo Kozai-Lidov (KL) oscillations driven by the SMBH, which may induce the binary eccentricity to extend up to values on the brink of unity and facilitate the merger. Understanding what mechanisms regulate the formation of stellar-mass BHBs around an SMBH remains a partly open question of recent astrophysics. The larger density and escape velocities in galactic nuclei can allow merged BH retention and recycling, possibly resulting in GW sources notably different from those originating via other formation channels. Moreover, the presence of an SMBH might leave some information within the GW signal, counting on the SMBH-BHB orbital properties.