Contribution ID: **476** Type: **Poster**

Cosmic inventory of the background fields of relativistic particles in the Universe

The extragalactic background is composed of the emission from all astrophysical sources, both resolved and unresolved, since the epoch of reionization, in addition to any diffuse components of exotic nature. In the last decade, there has been significant progress in our understanding of the cosmic history of extragalactic emissions associated with stellar evolution and accretion onto supermassive black holes, largely enabled by the extensive body of multi-wavelength data. The brightness of the extragalactic sky is now measured in photons, neutrinos, and cosmic rays, using observatories on the ground, in the sea, and in the ice, satellites in Earth orbit, and probes at the edge of the solar system. This wealth of disparate data is essential to unraveling the mysteries of the source populations that contribute to the extragalactic background and understanding the origin of their power.

In this contribution, we present an open database containing the most comprehensive collection of multi-messenger measurements of the extragalactic background spectrum to date. The convergence of direct measurements, galaxy counts, and indirect measurements is remarkable, except in the radio band where an observational controversy remains. The combination of multi-messenger measurements over 27 frequency decades allows us to estimate the energy density of most extragalactic background components with an uncertainty of less than 30%. We explore the consistency of this cosmic inventory of the observed fields of relativistic particles populating the Universe with the cosmic history of star formation and accretion around supermassive black holes. Models incorporating these cosmic histories, as well as the redshift-dependent luminosity functions of extragalactic sources, currently match the electromagnetic component of the extragalactic background spectrum over 14 frequency decades, from the near UV to sub-TeV gamma rays. The knowledge gained from synthetic population models in the electromagnetic bands may become a crucial tool for understanding the origin of the most energetic extragalactic messengers, neutrinos and ultrahigh-energy cosmic rays.

Collaboration(s)

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Session Classification: PO-2

Track Classification: Gravitational Wave, Multi-Messenger & Synergies