

Neutrino Tomography of Accretion Disks

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February 4, 2025

Abstract

Neutrino interactions in the vicinity of accretion disks around supermassive black holes provide a unique opportunity to study the properties and dynamics of these astrophysical structures through neutrino tomography. This paper explores the theoretical framework and potential methodologies for using scattering events of neutrinos in magnetized accretion disks to infer their composition, magnetic field structure, and plasma dynamics. We aim to establish a model that links detectable neutrino signals to the underlying physical mechanisms of the accretion process.

1 Introduction

The study of supermassive black holes (SMBHs) is crucial to understanding the dynamics of galaxies and the universe. Accretion disks around SMBHs are believed to emit high-energy neutrinos, which can serve as probes of the conditions within the disks. The weak interaction of neutrinos allows them to escape from dense environments, retaining information about the processes that generated them.

2 Theoretical Framework

Neutrinos are produced in various astrophysical processes, including the decay of pions and muons generated in cosmic ray interactions and nuclear reactions in the accretion disks. The emitted neutrinos interact with the magnetic fields and matter of the disk, leading to spin oscillations and flavor transitions. The survival probability of neutrinos is influenced by their trajectory through the disk, the magnetic field configuration, and the plasma density.

3 Methodology

To achieve neutrino tomography, we propose the following methodology:

1. **Modeling the Accretion Disk:** Use hydrodynamic simulations to model the structure of the accretion disk, incorporating factors such as density, temperature, and magnetic fields.

2. **Neutrino Production Rates:** Calculate the expected neutrino production rates based on particle interactions and decay processes occurring in the disk.
3. **Neutrino Propagation:** Develop a framework to study neutrino propagation, scattering, and spin oscillations in the disk's magnetic environment and compute the survival probability for various incoming angles.
4. **Comparison with Observations:** Compare theoretical predictions with observational data from neutrino telescopes to refine models of the accretion process and infer physical parameters of the disk.

4 Discussion

Neutrino tomographic techniques can provide insights into the temperature, density, and magnetic field structure of accretion disks. Understanding these parameters can lead to a deeper comprehension of accretion mechanisms and SMBH growth.

5 Conclusion

The potential for neutrino tomography offers a new frontier in astrophysics, enabling researchers to probe the otherwise inaccessible interiors of accretion disks around SMBHs. Future developments in both observational techniques and theoretical models are crucial for harnessing the power of neutrinos in this context.