X-Ray Emitting Supermassive Nuclei of the Local Group

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Abstract

In this talk, we will focus on a theoretical interpretation of what we have learned with recent *Chandra* observations of the supermassive black hole at the Galactic center (Sgr A*) and in the nucleus of M31 (M31*).

The recent detection of Sgr A* in the X-ray band, together with the radio polarization measurements conducted over the past few years, offer the best constraints yet for understanding the nature of the emitting gas within several Schwarzschild radii (r_S) of this object. It now appears that the sub-mm radiation from this source may be associated with thermal synchrotron emission from an inner Keplerian region within the circularization radius of the accreting plasma. In this talk, we discuss the implied high-energy emission of Sgr A* associated with the orbiting, hot, magnetized gas. For the accretion rate inferred from the fits to the sub-mm data, the dominant contribution to Sgr A*'s X-ray flux is due to self-Comptonization of the radio photons, rather than from bremsstrahlung. The latter is a two-body process, which would produce significant X-ray emission only at much higher accretion rates. This picture leads to the testable prediction that the physical conditions within the inner $\sim 5r_S$ are variable on a time scale of order a year. In particular, the accretion rate $\dot{M}$ appears to have changed by about 15% between the sub-mm measurements in 1996 and 1999. Given that the radio and self-Comptonized fluxes are strongly correlated, upcoming multi-wavelength observations of Sgr A* may provide the direct evidence required to test this picture.

M31* has many features in common with Sgr A*, yet they differ in several significant and important ways. Though M31* is probably ten times heavier, its radio luminosity at 3.6 cm is only one third that of Sgr A*. At the same time, M31* is apparently thousands of times more luminous in X-rays than its Galactic Center counterpart. Thus, a comparative study of these objects can be valuable in helping us to understand the underlying physical basis for their activity. We will discuss how the accretion model developed for Sgr A* comprises two branches of solutions, distinguished by the relative importance of cooling compared to compressional heating at the radius r_C where the ambient gas is captured by the black hole. For typical conditions in the ISM, the initial temperature ($T[r_C] \sim 10^6 - 10^7$ K) sits on the unstable branch of the cooling function. Depending on the actual value of $T(r_C)$ and the accretion rate, the plasma settles either onto a hot branch (attaining a temperature as high as $10^{10} K$ or so at small radii) or a cold branch, in which T drops to $\sim 10^4$ K. Sgr A* is presumably a 'hot' black hole. We show here that the VLA, UV and *Chandra* observations of M31* reveal it to be a member of the 'cold' black hole family. We discuss several predicted features in the spectrum of M31* that may be testable by future multi-wavelength observations, including the presence of a prominent UV spike (from hydrogen line emission) that would be absent on the hot branch.

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