Submillimeter Properties of Sagittarius A*: The Polarization and Spectrum from 230 to 690 GHz and the Submillimeter Array Polarimeter

A thesis presented

by

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to

The Department of Astronomy

in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy
in the subject of
Astronomy

Harvard University
Cambridge, Massachusetts

31 August 2006

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Abstract

Sagittarius A* is the supermassive black hole at the center of our galaxy; as the nearest example of a low-luminosity active galactic nucleus it provides an excellent opportunity to understand these objects. Submillimeter data are particularly important for examining this source because of the unique polarization and spectral features in this band. In this thesis I report several new observations of the polarization and spectrum of Sgr A* obtained with the Submillimeter Array (SMA).

I present the first measurement of Faraday rotation in Sgr A*. The rotation measure is $(-5.6 \pm 0.7) \times 10^5$ rad m^{-2}, restricting the accretion rate to the range 2×10^{-7} to 2×10^{-9} $M_\odot$ yr^{-1}. These boundaries jointly increase if the magnetic field is sub-equipartition or disordered. The stability in the rotation measure limits accretion variability to 25%. I find large variations in the linear polarization on timescales of minutes to months, the first measurements of variability on intraday timescales. I report the observation of an interesting polarization variation that may lead to future measurements of the black hole spin. I am also able to identify variations in the intrinsic polarization direction of the source. These results demonstrate the utility of polarization for examining changes very close to the black hole. Finally, I show that the spectrum of Sgr A* peaks around 350 GHz, limiting the luminosity of the source to 200 $L_\odot$, or $10^{-9} L_{\mathrm{E}}$.

The majority of these results rely on observations obtained with the polarimeter

I constructed for the SMA. I discuss the design and testing of the instrument and its expected performance. I review the principles of interferometric polarimetry, polarization calibration, and the origins of non-ideal response (or “leakage”) in the polarimeter. Extensive calibration observations show that the leakages are extremely stable and exhibit the frequency behavior expected from theory. The precision of the calibration represents a factor-of-several improvement over that attained with the most similar instrument elsewhere; these careful measurements are crucial for other results in this thesis. The polarimeter now operates as a facility instrument of the SMA.