Radio Emission and the Timing Properties of the Hard X-ray State of 

Michael P. Muno, Ronald A. Remillard, Edward H. Morgan, Department of Physics and Center for Space Research, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139 nuno@mit.edu, ehm@space.mit.edu, rr@space.mit.edu Elizabeth B. Waltman Remote Sensing Division, Naval Research Laboratory, Code 7210, Washington, DC 20375 ewaltman@rsd.nrl.navy.mil Vivek Dhawan, Robert M. Hjellming National Radio Astronomy Observatory, Socorro, NM 87801 vdhawan@aoc.nrao.edu Guy Pooley Mullard Radio Astronomy Observatory, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE ggp1@cam.ac.uk

abstract

We combine a complete sample of 113 pointed observations taken with the Rossi X-ray Timing Explorer between 1996–1999, monitoring observations taken with the Ryle telescope and the Green Bank Interferometer, and selected observations with the Very Large Array to study the radio and X-ray properties of when its X-ray emission is hard and steady. We establish that radio emission always accompanies the hard-steady state of, but that the radio flux density at 15.2 GHz and the X-ray flux between 2–200 keV are not correlated. Therefore we study the X-ray spectral and timing properties of using three approaches: first, by describing in detail the properties of three characteristic observations, then by displaying the time evolution of the timing properties during periods of both faint and bright radio emission, and lastly by plotting the timing properties as a function of the radio flux density. We find that as the radio emission becomes brighter and more optically thick, 1) the frequency of a ubiquitous 0.5–10 Hz QPO decreases, 2) the Fourier phase lags between hard (11.5–60 keV) and soft (2–4.3 keV) in the frequency range of 0.01–10 Hz change sign from negative to positive, 3) the coherence between hard and soft photons at low frequencies decreases, and 4) the relative amount of low frequency power in hard photons compared to soft photons decreases. We discuss how these results reflect upon basic models from the literature describing the accretion flow around black holes and the possible connection between Comptonizing electrons and compact radio jets.