THE COMPLEX CAVITIES, SHOCKS, AND NUCLEUS OF THE EXTREME AGN OUTBURST IN RBS 797

Over the last decade, X-ray observations have revealed numerous examples of the complex interaction between the relativistic outflows from active galactic nuclei (AGN) and the hot halo of the host galaxy [*e.g.* 1]. Shocks and cavities resulting from the AGN outflow-halo interaction provide a direct measure of the pV work performed on the halo and thus are useful for estimating the total energy of an AGN outburst [see 2, for a review]. Using cavities as calorimeters, studies have shown that AGN release $\sim 10^{55-62}$ erg of energy at rates of $\sim 10^{41-46}$ erg s^{-1}, sufficient to offset a significant amount of the radiative losses of the host halo [*e.g.* 3]. Further, in these systems, short halo cooling times, the appearance of multiphase gas, host galaxy star formation rates, and AGN activity are closely correlated [4–7], indicating the presence of a fine-tuned cooling-heating feedback loop. These results have shaped prevailing galaxy formation models such that they now utilize AGN feedback as the primary means for regulating late-time galaxy evolution [*e.g.* 8, 9]. Though our understanding of AGN feedback has improved greatly, the details of how AGN are fueled, the importance of shocks in heating cluster cores, how multiple gas phases are uplifted/mixed, and the role AGN have in re-distributing metal enriched gas remain elusive.

Of particular interest are extreme AGN outbursts ($E \gtrsim 10^{61}$ erg) in gas-poor hosts, such as Cygnus A, Hercules A, Hydra A, MS 0735.6+7421, and RBS 797 [10–14]. With the exception of RBS 797, large-scale shocks, metal-enriched outflows, and gas mixing have been detected in these systems and directly linked to the AGN activity. The extreme nature of the interaction in these systems provides a unique opportunity to better understand similar processes in more common lower power systems where detecting shocks or mixing requires prohibitively long exposure times. In addition, the mass accretion processes which can supply fuel to power these extreme outbursts are strained to the point of unrealistic efficiencies, which has led to speculation that some galaxies may host an ultramassive, or maximally spinning, supermassive black hole (SMBH) [15, 16]. These rare systems are thus important targets for studying the general process of AGN feedback, and in this proposal we focus on RBS 797, one the most powerful AGN outbursts currently known but which has the shallowest X-ray data that is insufficent to study shocks, metal enrichment, and mixing. **Thus, we propose to obtain a XX ks observation of RBS 797 to....**

Why RBS 797? Analysis of the cavities and large-scale shock in MS 0735.6+7421 using the X-ray data alone provides good limits on the outburst energetics, gives reasonable constraints on the age of radio lobes, but says little about the jet/lobe compositions and radiative efficiencies. The inclusion of broadband radio data addresses these disparities by making it possible to take a complete census of the radiating particle population. MS 0735.6+7421 is a steep-spectrum radio source, $\alpha > -2$, so it is critical to our science objectives to obtain radio observations at the lowest frequencies possible where the cavity system stores a tremendous amount of energy in old radiating populations distributed over large-scales. The 74 MHz data, in particular, is essential to the study of MS 0735.6+7421 because it extends our knowledge of the radio spectrum into the frequency regime where the break frequency is reliably estimated.

– two deep cavs with symmetric ridge around them... just like CygA, HercA, MS07! – low freq emission beyond cavs along axis of small-scale, nuclear jets... multiple black holes? projection effects? earlier epoch of activity? – bright nuclear source good for studying accretion – multiple resid structures may be an even richer cav sys

What will be new? By combining the total energy estimates from the X-ray analysis and the synchrotron energy estimates from the radio analysis, the jet and lobe magnetic field strengths, compositions, radiative efficiencies, environmental pressure balance, degree of confinement, and deviation from equipartition can be calculated and inferred [*e.g.* 17–23]. We can also investigate secondary processes such as matter entrainment and gas shocking by respectively mapping radio source composition and comparing cavity dynamical ages with synchrotron age estimates [*e.g.* 11, 22]. In addition, the low-frequency radio emission (and most definitely at 74 MHz) may reveal larger cavity volumes where higher frequency emission has faded, thus providing better cavity volume estimates and improved constraints on the MS 0735.6+7421 outburst energetics. In these ways, the synergy between the X-ray and radio observations provide vital information on the AGN outburst and an rare outlier in the general process of AGN feedback.

Request for Observations:
Previous *Chandra* Programs:

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