A Chandra X-ray Study of the Nucleus of Cygnus A

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Abstract

We report sub arc-second resolution X-ray imaging-spectroscopy of the nucleus of Cygnus A with the Chandra X-ray observatory and quasi-simultaneous observations with RXTE. The Chandra image shows an unresolved hard X-ray source coincident with the radio core. At lower X-ray energies this source has a bipolar morphology extending $\simeq 1.8$ kpc towards both the northwest and southeast, approximately along the direction of the radio jet and counter-jet, respectively. The bipolar morphology may be due, in part, to the presence of a dust lane running north-south across the nucleus. The soft X-ray emission is well correlated with HST images of [O III] and Hα + [N II] line emission.

Cygnus A has a heavily obscured active nucleus. We have extracted a spectrum of the nucleus from our Chandra data and, in addition, obtained a hard X-ray spectrum with RXTE of the $\simeq 1^\circ$ field centered on Cygnus A. We have combined these spectra to determine the power law slope of the nuclear emission, and the column density of the obscuring gas. The nucleus is well described by a power law of photon index $\Gamma = 1.52$ obscured by a column density of $N_H = 2 \times 10^{23}$ cm^{-2}. The rest-frame $2 - 10$ keV unabsorbed luminosity is $L_X(\mathrm{nuc}) = 3.5 \times 10^{44}$ erg s^{-1}. The Chandra spectrum of the nucleus shows emission lines from highly ionized Ne, ionized Si, and neutral Fe, and a strong Fe absorption edge.

The bipolar nebulosity extending towards the northwest and southeast is consistent with being electron-scattered light from the nucleus. The column density towards, and intrinsic to, the soft X-ray emission is not significantly in excess of the Galactic column density. Therefore, in order to have a sufficiently low soft X-ray opacity, the bulk of the scattering electrons must be at least mildly ionized with $\xi = L_X/[n_e R^2] \gtrsim 1$. In such a model approximately 1.2% of the intrinsic nuclear luminosity is electron-scattered into our line of sight.

CATEGORY: ACTIVE GALAXIES AND QUASARS