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VLBA Studies of Molecular Gas toward Centaurus A

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Abstract. We observed the four OH 18 cm transitions against the Cen A VLBI source. With high spatial resolution we detect the same molecular absorption as previously seen with ATCA. Both the excitation and VLBI absorption suggest a cloud size of $\lesssim 1$ pc.

1. OH Absorption and Emission toward Cen A

Centaurus A is not only a VLBI radio source, but against the strong millimeter continuum many molecules in a number of narrow absorption complexes are detectable (Israel et al. 1991; Eckart et al. 1990). With the ATCA absorption—and in some cases emission—was detected previously in all 4 OH ground state transitions (van Langevelde et al. 1995). The Very Long Baseline Array observed all four transitions simultaneously in dual polarization. Each 2 MHz band is divided into 512 spectral channels, yielding a spectral resolution of 0.7 km/s. The synthesized beamwidth of these VLBI measurements is 13 mas.

The VLBA spectra (Fig 1) confirm our ATCA results, in particular the fact that the OH satellite lines show very peculiar conjugate profiles, with weak maser emission. This effect is understood as maser competition in pc–size OH clouds (van Langevelde et al. 1995). The analysis predicts that the observed effect corresponds to a specific OH column density, where FIR pumping lines become optically thick. Comparing this column density with the total optical depth of the main lines, it has been estimated that the size of the molecular clouds is $\lesssim$ 1 pc (assuming an OH fractional abundance of $3 \cdot 10^{-7}$).

2. Location of the Absorbing Material

The deepest 1667 MHz feature occurs at the systemic velocity and could be caused by absorption in the circumnuclear torus or further from the nucleus. The 1665 MHz line is predominantly seen slightly blue–shifted from the 1667 line and it most likely originates in the dust lane in the outer parts of the galaxy. Both lines show broad absorption at red–shifted velocities, probably from gas close to the AGN. The features at the systemic velocity can be detected against the main VLBI source and also against the extended component in the VLBA data. As there is no noticeable change in the OH optical depth when we start to resolve the the VLBI source, we conclude there is no structure between 1–0.5 pc (60–30 mas).

At red–shifted velocities we have not been able to detect the absorption, because of insufficient sensitivity. It has been claimed that the red–shifted features arise from clouds falling into the nucleus, possibly feeding the black hole. However, recent VLBI continuum observations (Jauncey et al. 1995; Tingay et al., these Proceedings, p. 87) indicate that at 18 cm the main VLBI source is not

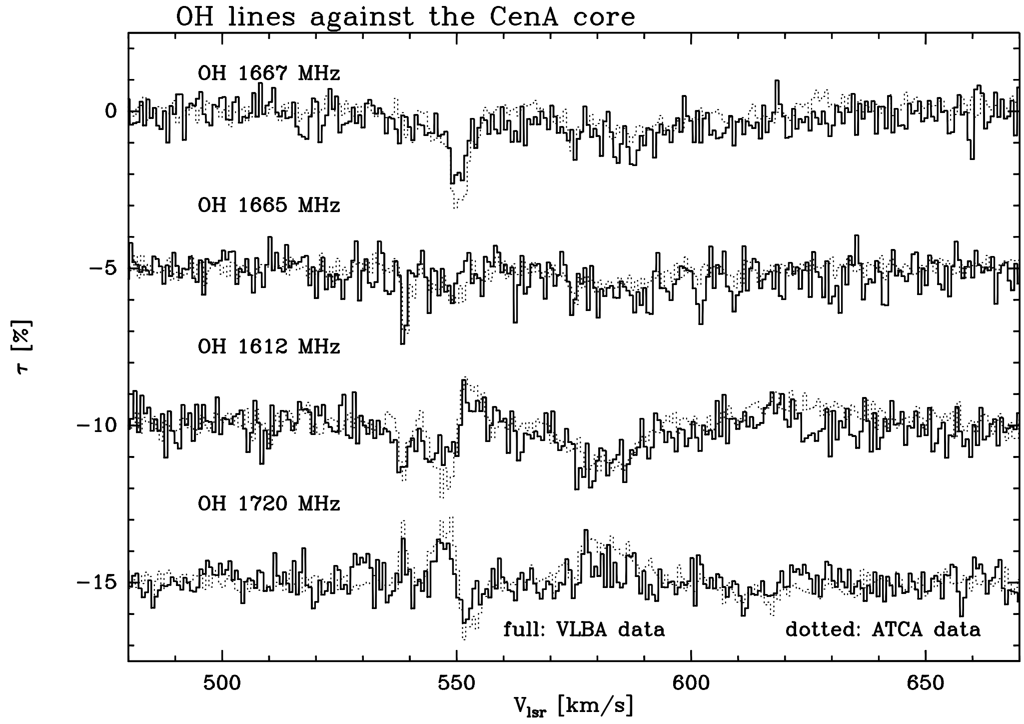

Figure 1. Spectra for all four OH ground transitions. The heavy lines are the VLBA results, the underlying grey lines reflect our previous ATCA results in a much larger beam.

the core but a bright spot in the jet, 15–20 mas away from the core. In principle this allows an interpretation of rotation for the red–shifted absorption. However, this interpretation requires a fat or warped molecular torus. A possible test is to observe lines at higher frequencies where the emission is dominated by the core. There seems to be no red–shifted absorption at H_2CO and NH_3 (Seaquist & Bell 1990), but at millimeter wavelengths many red–shifted features can be seen in spectra of HCO^+ and CO (Israel et al. 1991).

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