MASERS IN STAR FORMING REGIONS

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OH and H_2O masers in star forming regions are important because they are readily detectable indicators of star formation and because they provide unique information on the kinematics and physical conditions in high density regions (10^6 - $10^{10}cm^{-3}$) surrounding young stars, regions which cannot be studied by other means at present. The Jodrell Bank MERLIN interferometer has been used to map a sample of OH and H_2O masers associated with bipolar molecular outflows. The maps of Cepheus A show that the masers are closely associated with the densest compact H II regions at the centre of the flow. The masers appear to be located at the inner edges of the circumstellar disk thought to play a role in collimating the outflow. It is suggested that the H_2O masers trace the interaction between the stellar wind and the dense molecular gas, and the OH masers trace shocks propagating into the molecular gas. Rapid and sometimes correlated variations in the maser emission suggest that radiative pumping is likely in this source (Rowland and Cohen, Mon. Not. R. Astr. Soc. in press). Study of the other sources is still in progress.

A radio-selected sample of OH maser sources from Caswell and Haynes (1983, Aust. J. Phys. 36, 361) has been identified with IRAS point sources. The OH masers are such bright FIR sources that FIR pumping of the masers is feasible and needs to be seriously reconsidered. It should be possible to detect many new OH maser sources by their FIR counterparts in the IRAS point source catalogue. A pilot survey at 1665 and 1667 MHz of the brightest FIR sources, carried out jointly at Jodrell Bank and at Hartebeesthoek Radio Astronomy Observatory, has yielded 19 new OH maser sources. Many have no obvious radio continuum counterpart, and are presumably very young objects. The maser sources are brighter and marginally redder than the FIR sources without detectable OH maser emission (Cohen, Baart and Jonas, Mon. Not. R. Astr. Soc. in preparation).

RODRIGUEZ: In your geometrical model the H_2O masers would appear to form in a toroidal structure around the central object. Do you have evidence for this in several sources?

COHEN: There is good evidence for a torus of OH masers in Orion-KL (Norris 1984). We are currently investigating a wider sample of bipolar outflow sources to see how general this is.

FORSTER: Our VLA study of $\sim$ 70 OH/H_2O maser associations gives a picture somewhat different from what you have indicated. The OH masers generally appear distributed over the face of extended H II regions, and the H_2O masers extend farther out than the OH. Secondly, I agree with your feeling about the importance of linear polarization measurements of maser sources. We have undertaken a study of OH and H_2O

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linear polarization from the 70 OH/H_2O associations mapped at the VLA in order to compare their polarization directions with the maser and H II morphology. This data is currently being analyzed.

HUGHES: A much higher resolution map of Cep A, at 0.3", shows that the H_2O masers are situated all at the edge of the H II region, while the OH masers are well outside. We attribute this to a stage in the development of the H II region as summarized in the Abstract of the paper by Hughes. The presence and position of H_2O and OH masers is then a property of the age of the H II region and of the spectral type of the exciting star.

COHEN: I agree that the age of the region is very important in this respect.

REID: You claim that OH masers are observed at the limbs of shock-expanding shells. This is not in agreement, *statistically*, with the results of Garay, Reid, and Moran (1985) which show that masers preferentially lie toward the center of the H II emission.

COHEN: It is important to have accurate radio positions and high angular resolution. In one case that we have looked at, OH 45.1, the OH masers clearly lie around the edge of an H II shell seen in a high resolution VLA map by Turner and Matthews (1984), whereas they appear on the *face* of the H II region in the lower resolution map by Garay *et al.* I think the question needs to be looked at more carefully.

MODELS OF SHOCK ACTIVITY IN THE BN-KL REGION OF ORION

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The observed H_2, CO, OI(63 μm), SiII(34.8 μm) and H51α emission line intensities in the BN-KL region of Orion are modeled as arising from two types of shock waves. The molecular emission arises from non-dissociative shocks with low peak postshock temperatures (< 3000 K), traveling at speeds of $v_s \sim 40$ km/s into ambient gas of density $n_0 \sim 10^{5-6}$ cm^{-3} and transverse magnetic field $B_0 \sim 0.5$ milligauss. The OI(63 μm), SiII(34.8 μm) and H51α emission arises in the cooling regions behind faster (~ 80 km/s) dissociative shocks with high peak postshock temperatures ($\sim 10^5$ K) and with preshock densities $n_0 > 3\times10^4$ cm^{-3}.

A simple global model is proposed to explain the source of these two characteristics shock waves. A wind from IRc2, characterized by a speed $v_w \sim 120$ km/s and $\dot{M} \sim 5\times10^{-3}$ $M_\odot$/yr, drives clouds at velocity $v_s \sim$ 40 km/s into ambient molecular gas in KL. The wind striking the cloud

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