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RADIO OBSERVATIONS OF THE OH RADICAL IN COMETS KOBAYASHI-BERGER-MILON (1975h) AND WEST (1975n)

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The radio observations of the 18 cm wavelength OH main lines in comets Kobayashi-Berger-Milon (1975 h) and West (1975 n) confirm the model of ultraviolet pumping by the sun, that we proposed to explain our previous observations of comet Kohoutek (1973 f). The OH scale length in (1975 n) is at least 10^6 km at a heliocentric distance of 1 AU, in agreement with that for (1973 f).

Observations of OH in comets can throw some light on one of the major parent molecules and therefore on the cometary chemistry and their origin.

The observations of the main lines of OH at 18 cm wavelength in comet Kohoutek (1973 f) were described and interpreted in a previous paper (Biraud *et al.* 1974, hereafter referred to as Paper I). The same interpretation was independently suggested by Mies (1974). Both analyses support the following model: the cometary OH is pumped by the ultraviolet solar radiation which produces a population inversion in the ground state Λ doublet $^2\pi_{3/2}$ (J = 3/2). Because of the Doppler shifted Fraunhofer spectrum, the inversion is extremely sensitive to the heliocentric radial velocity as illustrated on Fig. 1. In the range -60 to +60 km s^{-1} the predicted inversion reaches peak absolute values greater than 0.3 at five heliocentric radial velocities namely -50, -20, -8, +32 and +42 km s^{-1}.

OH was observed in comet Kohoutek (1973 f) in absorption near -50 km s^{-1} (Paper I and Turner (1974)) and in emission near +42 km s^{-1} (Paper I); in February 1974 the OH signal should have reversed again to absorption but we failed to detect it probably because the Comet was considerably fainter than before perihelion.

Comet West (1975 n), with nearly the same perihelion distance (q = 0.19 AU) as comet Kohoutek (q = 0.14 AU), fortunately behaved in just the opposite way: its nucleus disintegrated into four fragments and the outgassing was considerably larger after perihelion. Webber *et al.* (1976 a,b) observed it in emission near +42 km s^{-1} heliocentric radial velocity; their result was confirmed by Bowers (1976). In March and April 1976 the Comet was observed with the Nancay radiotelescope, first in emission, then in absorption near +32 km s^{-1} (Gerard *et al.* 1976).

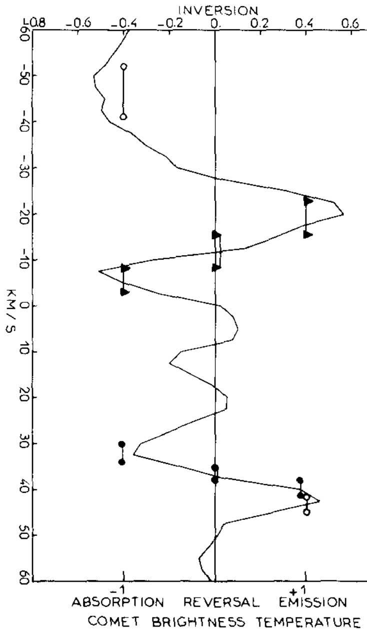

Figure 1. Predicted population inversion in the ground state Λ doublet of OH versus the heliocentric radial velocity: full line.
Observed cometary brightness temperature : 1 for a signal in emission
: 0 for a signal reversal
:-1 for a signal in absorption.

Comets : Kohoutek (1973 f); empty circles
: West (1975 n) ; filled circles
: Kobayashi-Berger-Milon (1975 h) ; triangles.

The last two maxima of inversion near -20 and -8 km s^{-1} could not be studied with adequate signal to noise ratio, neither with comet Kohoutek nor with comet West: Comets with small q rapidly sweep through the low heliocentric radial velocity range and do not allow long integration times. With a perihelion distance of 0.4 AU, Comet Kobayashi-Berger-Milon was better suited for exploring the two inversions. The observations were carried out from August 26 through September 4, 1975, with both the Dwingeloo 25-m radiotelescope* and the Nancay radiotelescope. At Dwingeloo, the comet was successfully detected in emission near heliocentric radial velocity -20 km s^{-1} and the signal later changed to weak absorption. At Nancay we marginally observed the Comet in emission at -20 km s^{-1}.

The brightness temperatures that we recorded on comets (1973 f), (1975 h) and (1975 n) were very different in intensity due to the large variation of the following parameters: 1. The OH production rate. 2. The heliocentric distance r. 3. The geocentric distance Δ. 4. The telescope beamwidth. We are presently processing all data available on the three Comets and fitting them into a model for the OH volume density in order to study the evolution of the "radio" OH cloud; this work will be published later along with a detailed description of the radio observations. In Fig. 1 we only give the brightness temperature in

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qualitative form. The excellent agreement between observation and theory leaves little doubt as to the validity of the model of ultraviolet pumping of the OH molecule by the Sun; thus one can apply Equation (2) of Paper I to calculate the OH column density, $<N_{OH}>$, averaged over the solid angle subtended by the antenna beam.

The next problem we wish to study is that of the OH scale length γ_{OH}. From U.V. observations of the λ3090 Å band Blamont and Festou (1974), Keller and Lillie (1974) find that γ_{OH} at r = 1 AU could be as small as 8 x 10^4 km; *i.e.*, 1.8 ' at Δ = 1 AU. If so, there is little hope to measure the variation of N_{OH} versus the distance from the nucleus, r, with existing single dish radiotelescopes whose angular resolution ranges from about 3' to 30' at 18 cm wavelength. However, already in Paper I, we pointed out that $<N_{OH}>$ for comet Kohoutek in early December 1973 was only 2.2 times larger at Nancay than at Green Bank, whereas the antenna beam is 5 times smaller at Nancay (3.5' EW x 19' NS) than at Green Bank (18' x 18'). From the simple model described in Paper I it follows that γ_{OH} must be larger than 8.105 km at r = 1 AU, *i.e.*, 10 times the currently accepted optical value. In order to clarify this matter we have attempted to measure the extent of the radio emission of comet West with the Nancay radiotelescope, from 25 March through 30 March 1976. The telescope was tracking the position of the Comet and alternately a position one beamwidth (3.5') east or west from the nucleus. We find that the brightness temperatures east and west of the nucleus are the same and equal to 56% ± 20% of that measured at the center position. The OH coma is thus not a point source since the total flux density is more than 2.1 ± 0.4 of that measured with the antenna pointed at the nucleus.

The situation is very similar to that of comet Kohoutek in early December 1973 since both comets had nearly the same r and Δ. Accordingly one could expect the brightness temperature of (1973 f) to be less than 5/2.1 or less than 2.4 times larger at Nancay than at Green Bank as we indeed found.

In conclusion, the radio observation of an extended emission in comet West (1975 n) seems to imply again that γ_{OH} is at least 10^6 km at r = 1 AU. However, ultraviolet observations of OH, that are believed to be quite reliable, consistently yield a scale length in the range of 10^5 km, that is, one full order of magnitude shorter. The origin of this discrepancy is unknown and should be explored, because it can change the order of magnitude of the production rate of OH and therefore, the results deduced about the cometary chemistry.

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DISCUSSION

DELSEMME: If the radio-scale length of OH is 10 times as large as the optical scale length, you must have two different sources of OH, possibly a low-velocity

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source and a high-velocity source coming from the dissociation of a different parent molecule. Do you believe that?

GERARD: This is a possibility. However, it is too early to draw any definite conclusion since we do not know what the velocity of the "optical" OH is. In any case the OH velocity distribution is certainly not single peaked, thus the OH scale length is only a weighted average and one would rather use the OH lifetime in model computations. Also the radial outflow models with constant velocity distribution probably hold for the "radio" OH but the situation is more complex for the "optical" OH that arises in the inner coma where the densities are much higher and where other physical processes may be operating.

KELLER: The range of intensity of OH observed in the UV covers two orders of magnitudes. The observed extension goes out to about 4 x 10^5 *km, several scale lengths of OH. The optically observed extent of the OH cloud covers the full size of the lobe of the Nancay radiotelescope.*

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