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IO Andromedae is a quasar, rather than a cataclysmic variable

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Spectroscopic observations of the putative cataclysmic variable IO And have shown that it is a quasar with $z = 0.134$. In some respects it resembles bright type I Seyfert nuclei. Estimates of its radio and x-ray luminosity show that it is not a blazar, but it may possess spectral variability and rapid photometric variability in the visible.

The brightness variation of IO And has been studied by Meinunger (1975), who classified it as an irregular variable. In the fall of 1979, when the object's brightness was $B = 16.2$, Meinumger (1980) obtained two spectra. They were continuum spectra, and only at the Hα position was there the suggestion of a line, which was "washed out by emission or in weak absorption." On that basis, Meinunger suggested that IO And is an AM Her object.

The brightness variation of IO And was studied again by Andronov (1983) based on 1967-1985 photographic observations. He established that the B magnitude of IO And varies from $15^m.6$ to $17^m.4$ and brightness fluctuations with amplitude $\simeq 0^m.4$ are noted on a time scale ~ 0.5 h, but more rapid fluctuations are possible, and it was concluded that IO And is nova-like but is not an AM Her object.

We undertook spectroscopic observations of this object in connection with a program of investigation of nova-like objects. It was observed on 8-10 September 1986 with the 6-m telescope, using a television scanner. At that time, IO And had a brightness $B = 16.1$ (private communication from I. L. Andronov). We obtained six spectra with 100 Å/mm dispersion: four spectra in the 4250-6070 Å range and two in the 5350-7250 Å range. The sum of the first four is shown in Fig. 1. The spectrum contains emission lines that can be identified only by assuming that they are redshifted and ascribing a certain redshift z to them. The results of the identification with the measured wavelengths and the determined value of z are given in Table I. The average of these determinations is $z = 0.134$. No other spectral features were found that reliably exceed the recording noise. At the position of the putative shifted Hα line, there is a broad emission feature with a half-width $\simeq 100$ Å. Because of the low sensitivity of the receiver in that range, however, the noise is very high and the signal-to-noise ratio for the putative Hα is $\lesssim 1$, so we cannot state confidently that it is present.

We may thus conclude that, based on the properties of its emission spectrum, IO And is a quasar with $z = 0.134$. Not all of the observations are consistent with this conclusion, however. Andronov (1983) notes variability of the brightness of IO And from night to night and even in the course of one night. If this is real, such rapid variability is atypical of quasars. A second atypical feature is the absence of lines in the fall of 1979, when Meinunger (1980) obtained two spectra, one in the $\sim$4000-7000 Å range and the other in the $\sim$6000-7000 Å range. The first spectrum covers a larger wavelength range than is shown in Fig. 1, and strong emission lines could not have been overlooked. The brightness of IO And in the fall of 1979 was $B = 16.2$, i.e., the same as in our observations. We are left to suppose that the intensity of the emission spectrum varies with time.

Knowing z, we may estimate the distance to the object, 536 Mpc ($H_0 = 75$ km/sec·Mpc), and its absolute B magnitude, $M_B = -22^m.6$. For an Hβ equivalent width 46 Å, this gives a luminosity $3 \cdot 10^{42}$ erg/sec; these are close to the characteristics of bright type I Seyfert nuclei.

To clarify the nature of IO And (quasar, Seyfert galaxy, blazar), we attempted to find signs of a galaxy, and to estimate its radio and x-ray luminosity. In photographs of the Palomar Atlas, IO And has a star-like image. Attempts to find absorption features in its spectrum were unsuccessful. Only at the position of the G band, shifted by $z = 0.134$, might there be a weak absorption feature with an equivalent width $\simeq 0.7$ Å.

Observations with the RATAN-600 radio telescope on 27 May 1987 at 7.6 cm yielded an upper limit on the flux density $s_\nu < 15$ mJy, which corresponds to a radio luminosity $\log L_R < 30.7$ erg/sec·Hz. This is three orders of magnitude

TABLE I

Identification	λ_{meas}, Å	Halfwidth, km/sec	z
5007 [OIII]	5677	750	0.134
4959 [OIII]	5623	650:	0.134
4861 Hβ	5523	5100	0.136
4363 [OIII]	4942	700	0.133
4340 Hγ	4920	4600	0.133
4101 Hδ	4660	4600	0.136
3970 Hε	4495	4100:	0.132:

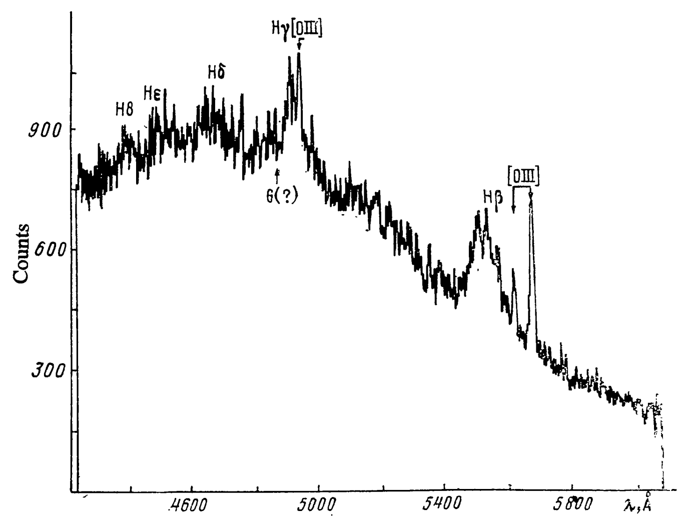

FIG. 1. Spectrum of IO And.

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lower than that of radio galaxies and an order of magnitude lower than that of radio-quiet blazars (Maraschi et al., 1986). The object IO And does not appear in the IRAS catalog. According to the A2 survey on HEAO 1 (Piccinotti et al., 1982), the upper limit of the luminosity of IO And in the 2-10 keV range is $\log L_X < 26.7$, which is lower than that of radio-quiet blazars at 2 keV, so IO And cannot be a blazar. It is probably a quasar, but some of its properties are anomalous and merit careful study.

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Flaring H_2O masers as a manifestation of a self-induced phase transition in the nonequilibrium interstellar medium

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An emission mechanism for powerful flaring H_2O masers is investigated. It is shown that a self-induced phase transition from incoherent H_2O maser emission to coherent emission can explain simply the behavior of some characteristics (anisotropy, variability, polarization, and spectral properties).

Introduction. In the last few years the observed powerful cosmic H_2O masers, including flare masers, have aroused great interest. The aim of this work is to analyze a possible mechanism for such flare. According to this mechanism, the flare phenomenon is interpreted as the appearance of coherent and cooperative effects in the nonequilibrium cosmic medium. Such effects have not been investigated in previous theoretical work, though the basic aspects of the process of amplification and evolution of the spectral properties of maser radiation were studied in the earliest work on the theory of natural cosmic masers (Litvak et al., 1966; Perkins et al., 1966; Strel'nitskii, 1974). Many important aspects of the theory of the coherence properties of maser radiation were analyzed in the course of astrophysical measurements of the coherent statistical properties of OH and H_2O maser radiation (Pashchenko et al., 1973; Evans et al., 1972; Rudnitskii, 1974; Lekht, et al., 1975; Slysh, 1976; Moran, 1981).

In spite of the fact that the result of these radio astronomical experiments was negative (they indicate that the maser radiation does not have coherent properties), a number of recently observed characteristics of the radiation from powerful H_2O masers indicate that such masers do have coherent properties. Thus, on the basis of an analysis of observational data on flare H_2O masers, Matveenko et al. (1988) concluded that such masers can have coherent properties and their radiation can be highly anisotropic. Ishankuliev (1990) showed theoretically that in all probability some powerful H_2O masers emit coherent radiation.

Most observed astrophysical masers do not exhibit coherent properties because the active medium of a cosmic maser with a wide Doppler-broadened line consists of an ensemble of molecules which participate in the thermal motion. Because a cosmic maser has no resonator, modes in such a maser traveling in different directions can be amplified within the inhomogeneous line width in the continuum, i.e., all modes which are distributed continuously within the gain line and for which amplification exceeds attenuation will participate in the maser radiation. The radiation will then be quasi-isotropic, i..e, it will consist of a collection of waves propagating in different directions in the cosmic medium.

Thus the radiation generated in a cosmic maser in such an amplification regime is the result of the stochastic addition of a large number of radio signals. In this case the maser radiation is a noise-like field. For this reason the fact that coherent properties have not been observed still does not mean that the cosmic masers cannot operate in the regime of coherent emission. This becomes possible, as follows from the arguments presented in this paper, when certain conditions are satisfied.

This paper is concerned with the evolution of stochastic maser radiation in the process of propagation, the effects of such radiation on the working molecules of the active medium, and the transformation of the characteristic properties of this radiation as a result of such interaction. It is shown that for high densities of inverted molecules or for sufficiently long effective lengths of the active medium, when the maser radiation can reach high intensities, the amplification process can change significantly as a result of the interaction of the intense stochastic maser radiation with the active molecules. As a result, when saturation is reached the radiation regime can change, transforming from amplification of noise radiation to coherent radiation.

The mechanism by which the stochastic maser radiation changes the uniform relaxation parameters of the working

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