The IR energy distribution of SS433

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SS433 is an extraordinary emission-line object showing periodically varying velocities of up to 30,000 km s\(^{-1}\) (refs 1, 2). It is also a variable radio source\(^3\) and an X-ray source\(^4\). Infrared observations of SS433 in the 1-4 \(\mu\)m range have been reported elsewhere\(^5-10\). The data that we present here include observations at 1-10 \(\mu\)m and indicate first that there are substantial infrared colour variations from night to night and second that there is a sharp long-wavelength cutoff in the IR energy distribution, which was not seen in the earlier, more limited data. The discovery of this cutoff allows the diameter and electron density of the emitting region to be estimated.

Photometric measurements were made on the nights of 29, 30 and 31 May 1979 UT, using the University of Hawaii 2.2-m telescope on Mauna Kea. The 1.2-4.8 \(\mu\)m observations employed an InSb detector and a 6 arcsec diaphragm while the broadband 8-13 \(\mu\)m observations used a gallium-doped germanium bolometer and a 6 arcsec diaphragm. On each night all the observations were completed within 20 min of the mean time given in Fig. 1, except that the 10 \(\mu\)m observation on the 29 May was made about 2.5 h earlier than the time quoted.

Figure 1 shows that between 1.2 and 4.8 \(\mu\)m substantial night-to-night variations exist with a suggestion that the variations are stronger at longer wavelengths. Unfortunately, no 10 \(\mu\)m data are available for 31 May, but a later observation by Becklin and Telesco, made during the commissioning of the 3.0-m NASA IR Telescope Facility on 1979 June 14.4 gave a 10 \(\mu\)m flux density of \(\log S_\lambda = -26.82 \pm 0.04\) a factor of 30% less than that observed 15 days earlier. At the same time C. Lonsdale and H. M. Dyck (personal communication) measured a 2.2-\(\mu\)m flux density of \(\log S_\lambda = -26.54 \pm 0.04\), a value lower than earlier measurements. The IR night-to-night variations of both flux density and colour therefore seem to be substantially larger than those reported in any other wavelength range.

The proposal by Giles et al.\(^5\) that the IR emission from SS433 is due to reddened free-free emission from an ionised plasma provides a natural explanation for the shape of the energy distribution shown in Fig. 1, in that the decrease in flux density at wavelengths longward of 5 \(\mu\)m can be attributed to self-absorption. Although it is probable that the standard relationships for H II regions (see ref. 11) are inaccurate at the high column densities encountered in SS433, we may make estimates of the physical parameters of its emitting regions by assuming an electron temperature of 10^4 K and normal recombination theory. From the flux density (0.5 Jy) and the wavelength at the turnover frequency (5 \(\mu\)m) we can derive an angular diameter of order 2 \(\times\) 10^-4 arcsec and an emission measure \((N_e^2 dl)\) of the order of 10^{14} cm^-6. If a distance of 3.5 kpc is assumed\(^7\) we estimate a physical size for the emitting region of order 1 AU, an electron density of the order of 10^{15} cm^-3 and a photoionisation rate of 10^{-8} s^-1, a value that is similar to that of a late O type star.

Fig. 1 The IR energy distribution of SS433 on: •, 29.64 May 1979 UT; x, 30.51 May 1979 UT; O, 31.60 May 1979 UT.

The size derived here is comfortably smaller than any upper limits implied by the observed variability of the source, while the electron density is high enough to account for the weakness of the forbidden lines in the optical spectrum.\(^1\) The mass of ionised gas, assumed uniform density, is of the order of 10^{-7} M\(_{\odot}\).

If the IR radiation arises from free-free emission then a possible explanation for the fact that the variability is greater at longer wavelengths suggests itself. If an H II region is ionisation bounded its optically thin flux density is dependent on the rate of production of ionising photons, but almost independent of the geometry and electron density. At longer wavelengths, however, where self-absorption exists along at least some lines of sight the flux density is much more sensitive to changes in geometry, viewing angle and electron density. Further studies of the time variations of the IR energy distribution of SS433 may therefore help to determine the shape and the properties of its emitting region.

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