HM SAGITTAE - A MOST REMARKABLE STAR

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HM Sagittae is one of the most unusual objects in the Galaxy for it displays activity in every spectral band from x-ray to radio. Its present variable-star designation was given after the discovery of its optical brightening from 16^m to 12^m between April and September 1975 (Dokuchaeva and Balazs 1976). It was soon found to have a rich emission-line spectrum similar to that of a planetary nebula (Stover and Sivertsen 1977). Post-brightening monitoring of the object by Ciatti, Mammano and Vittone (1977, 1978) found the B and V magnitudes to be variable with amplitudes of at least one magnitude. Evidence for increasing excitation was found by Ciatti, Mammano and Vittone (1979) with HeII 4686 emerging in October 1978. Wolf-Rayet features of velocities up to 2000 km s^{-1} have also been seen (Belyakina, Gershberg and Shakhovskaya 1978, 1979; Brown *et al.* 1978; Ciatti *et al.* 1978; Wallerstein 1978; Allen 1980; Andrillat and Swings 1982). Analysis of the forbidden line ratios gives an estimated nebula density of 10^6-10^7 cm^{-3} and a gas temperature >10^4K (Ciatti *et al.* 1977; Arkhipova and Dokuchaeva 1978; Davidson, Humphreys and Merrill 1979; Arkhipova, Dokuchaeva and Esipov 1979).

Photospheric absorption bands of CO and H_2O have been detected by Puetter *et al.* (1979), suggesting the presence of an M giant. Thronson and Harvey (1981) confirmed these absorption features in 1979 but found the CO feature missing entirely in 1980. Thronson and Harvey also detected 8 members of the Brackett series in the 1.5-2.3 μm region. Using standard extinction curves, they derive a visual extinction (A_V) of 12^m. Most of the extinction is likely to be circumstellar, however. Davidson *et al.* (1978) found a strong infrared continuum with a colour temperature of ∿1000 K, together with a 9.7 μm silicate feature. This suggests an oxygen-rich system and the existence of a stellar wind from the cool component. Since most of the energy is emitted in the infrared, the total luminosity of the object can be estimated to be $\sim 4\times10^3$ (D/1 kpc)$^2 L_\odot$. Variations of the infrared continuum were noted by Slovak (1978) and further photometric observations by Taranova and Yudin (1980) show the variations to be consistent with a Mira variable with a period > 1 year.

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HM Sge also has a rich emission line spectrum in the ultraviolet (Feibelman *et al.* 1980). Widths of the CIII] lines indicate expansion velocities >120 km s^{-1} (Flower, Nussbaumer and Schild 1979). Narrow spikes observed on the broad CIII] line suggest emission from two separate components (Feibelman *et al.* 1980). Analysis of the optical line profiles by Wallerstein (1979) shows line widths of large disparity, ranging from 35 km s^{-1} for [NII] to 1700 km s^{-1} for Hα. This was interpreted by Kwok and Purton (1979) using an interacting-winds model where the wide permitted lines originate from a wind from the hot component, forbidden lines from the cool-star wind and forbidden lines of high critical densities from a dense shell formed by the interaction of the two winds.

Soft x-ray emission from HM Sge was detected by Allen (1981). He suggests that the x-ray emission has a thermal surface comparable to the size of a white dwarf and is probably excited by accretion or a thermonuclear runaway during the outburst.

Radio emission was first detected by Feldman (1977) in May, 1977. Since then the radio emission has undergone a continued brightening at frequencies between 1 and 15 GHz (see Kwok 1982). The radio spectrum is still optically thick in 1981 but it is expected to become optically thin (first at high frequencies) in the near future. High resolution maps made at the VLA show the object to be elongated along the NE direction (Kwok, Bignell and Purton 1982).

What is the cause of the optical brightening? With increasing evidence for the actual presence of an M giant, it seems unlikely that it is the result of the unveiling of the hot core of an M giant as suggested by Kwok and Purton (1979). It is possible that the brightening is the result of ignition of nuclear burning after a period of sustained accretion due to an increase in mass loss rate from the M giant. Willson (1981) suggests that such a sudden change in mass loss rate can be caused by the onset of Mira pulsation while the star is ascending the asymptotic giant branch. If wind accretion is the dominant mode of accretion then one must also be concerned about whether the accretion process would be disrupted by the possible initiation of another stellar wind from the compact component. If the accretion process is to remain steady, then the wind from the hot component cannot be spherically symmetric. A possible model is that accretion occurs on the plane of the accretion disk while the hot-star wind is concentrated only in the polar directions.

In summary, HM Sge is probably best described by a binary system consisting of a late M giant and a hot compact object which is similar to central stars of planetary nebulae. The presence of a wind from the M giant implies that Roche-lobe overflow is not a necessary condition for mass transfer. The complex structure of the circumstellar nebula is possibly the result of wind interactions. The ongoing spectral evolution of HM Sge after its recent outburst makes it an ideal candidate to test models of the symbiotic phenomenon.

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