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PROPERTIES OF OH/IR STARS WITH THE IRAS LRS SPECTRA

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ABSTRACT

1607 OH/IR stars associated with IRAS sources are assembled and the IRAS LRS spectra of 980 OH/IR stars are examined in this paper. The nature of the circumstellar dust for these sources is classified. The distributions of these subgroups of OH/IR stars in the IRAS color-color diagram and the period-color diagram are interpreted with their evolutionary status. The Galactic and the velocity distributions of these subgroups of OH/IR stars are also presented. The correlations among the expanding velocities of the envelopes, colors, periods and the pumping efficiencies for subgroups of OH/IR stars are investigated to outline the evolutionary status of OH/IR stars.

Key Words : OH/IR star – circumstellar matter – Evolution

I. INTRODUCTION

A complete data base of the "pre-IRAS" observations of OH/IR stars with 1612MHz emission has been compiled by te Lintel Hekkert et al.(1989). In this catalog, there are total 442 objects with IRAS associations. However, most of the energy of OH/IR stars is radiated by the cold circumstellar dust, especially between 2 and 60μm (Kleinmann et al. 1981). Therefore a reliable protocol in finding more OH/IR stars consists in selecting candidates from the IRAS Point Source Catalog (1988, Version 2, hereafter PSC). IRAS observations of known OH/IR stars shown that these stars defined a clear trend area in IRAS color-color diagrams (Olnon et al.1984). Their distinctive infrared colors make them easy to identify by such a color selection. Prompted by this result, after the IRAS mission, several systematic surveys have been taken to detect OH emission in the IRAS objects selected according to their color. The surveys include the Arecibo(Eder et al.1988; Lewis et al.1990; Lewis 1992; Chengalur et al.1993; Lewis 1994), the Dutch-Parks (te Lintel Hekkert 1990; te Lintel Hekkert et al. 1991), the Nancay (Sivagnanam et al.1988; 1989, 1990, Le Squeren et al.1992; David et al. 1993), the VLT (Zijlstra et al.1989; Lindqvist et al.1992; Blommaert et al.1994) and other individuals (Gaylard et al.1989; Galt et al.1989; Likkel et al.1989; te Lintel Hekkert 1991; Silva et al. 1993). The intensive OH emission surveys above and the availability of the IRAS data have made possible a comprehensive study of physical property and evolutionary status for OH/IR stars.

II. DATA ANALYSIS AND DISCUSSION

1607 OH/IR stars with IRAS association are assembled as our working sample in this paper. We have also examined the IRAS LRS spectra from Olnon & Raimoud (1986), Volk and Cohen (1989), Volk et al.(1991) and the IRAS Data Analysis Facility in the University of Calgary. Out of 1607 samples, 980 sources have LRS spectra available, of which 413 have original LRS number classification from Olnon & Raimoud (1986). In the catalog there are following information for each sources: IRAS name, LRS classification, colors, probability of variability, period, envolope expansion velocity, stellar radial velocity, interpolated flux density at 35μm, OH peakflux density at 1612MHz and Galactic position. Of 980 samples there are 57% in group E with silicate emission, 16% in group A with silicate absorption, 5.7% in group H with nebula feature, 3.4% in group P with PAH feature. It is surprising that 6 OH/IR stars belong to group C with 11.3μm SiC feature. It is important to investigate the last sources more in detail.

The IRAS color-colar diagram shows a gradual sequence with increasing in colors for groups E, A and H that is interpreted as continuous increasing mass loss rate and optical depth of circumstellar. This tendency indicates an evolutionary sequence of OH/IR stars from emission to absorption feature then to the planetary nebula phase, or/and an initial mass sequence (eg. Volk & Kwok 1988, Likkel 1989). The period-color diagrams show that the pulsation period increases with infrared colors, i.e. with mass loss rate for sources in groups E and A, but not for ones in group H. In fact, sources in the PPN or PN phase in group H should mostly be non-variable (Kwok 1987).

The Galactic distribution of working sample shows that sources in group E cover a wide latitude range, whereas sources in other groups are located not more than 10 degrees from the Galactic plane. This may imply that many sources in group E are different population and relatively nearby objects compared with sources in other groups. The positon difference may indicates that at least the color sequence in part is a mass sequence as suggested by Likkel (1989) and Volk & Kwok (1988)

The relation between interpolated flux density at 35μm and OH emission flux density shows that sources in group E are less than half as efficient as sources in group A in pumping the 1612 MHz maser. This is probaply due to the thin thickness of dust shell and the low optical depth for the group E sources. In any case it is concluded that the emission at 35μm is strong enough to pump the 1612MHz OH maser.

The color and period-envelope expansion velocity diagram shows that the expansion velocity increases with color and period for group E sources, but is stationary for redder color sources in groups A, P and H. According to Baud et al.(1981) the expansion velocity is a measurement of the main sequence mass so that sources in group E would have a wide range of initial mass whereas sources in other groups would comprise massive stars. From the relation of Galactic latitude–expansion velocity it is shown that sources with high expansion velocity (over 30km/s) are along with the Galactic plane, whereas in high latitude regions ($|b| > 15 degree$) there are no sources with the expansion velocity greater than 20 km/s. The former sources are thought to be most massive OH/IR stars and the latter are sources with low initial mass.

III. SUMMARY AND CONCLUSION

In this paper we present 980 OH/IR stars with the IRAS LRS spectra as a working group to investigate the properties of OH/IR stars by combining their characteristics in the infrared and the radio wavelength. It is shown that the majority of OH/IR stars have silicate feature either in emission or in absorption at the AGB phase. When the feature becomes absorption from emission, the color temperature is decreased, and the infrared color, optical depth, pulsation period, expansion velocity and pumping efficiency of OH/IR stars are increased, which reflects the increasing mass loss rate and initial mass. At the end of the AGB phase the pulsation is stoped, and consequently large mass loss rate is ceased as well, then OH/IR stars will evolve into the proto-planetary nebula phase. Although the source still exhibits OH emission in 1612 MHz and the color temperature is still decreased, the infrared color is still increased as well, the source is non-variable with an almost constant expansion velocity. From the properties gradully showing above in different phases, it can be concluded that the sequence of the sources with silicate emission to the sources with silicate absorption, then to the proto-planetary nebula phase presents a track of the evolutionary sequence and mass sequence for OH/IR star.

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