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THE FAR-INFRARED (IRAS) EXCESS IN ROBERTS 22 AND RELATED OBJECTS

M.PARTHASARATHY
Indian Institute of Astrophysics
Bangalore-560034,India

ABSTRACT: From an analysis of the IRAS data of Roberts 22,M1-92,M2-9,OH 231.8+4.2,M1-91,MWC 922,Hen 401,Mz-3,OH 19.2-1.0 and OH 26.5+0.6 it is found that the characteristics of the dust shells or disks around these objects are similar to that observed in planetary nebulae. These ten objects may be described as transition objects evolving from the tip of AGB towards left in the HR diagram. The bipolar and disk geometry of the dust envelopes around these objects may be the result of large angular momentum of the progenitor star or the central objects may be evolved binary systems embedded in thick disks formed from severe mass loss.

1.INTRODUCTION

Roberts 22 is a bipolar nebula and a strong OH maser source (OH 284.18-0.79) showing intense emission on both the 1612 MHz and 1665 MHz transitions (Allen et.al.,1980). The other objects similar to Roberts 22 are M1-92,CRL 618,CRL 2688,Red Rectangle (HD 44179),Hen 401,IRC +10420,M2-9,M1-91,Mz-3, and OH 231.8+4.2. Most of these objects show bipolar structure,infrared excess, and a large ratio of the fluxes f_{IR}/f_{vis}.

These objects are not associated with young stellar objects,and star forming regions. Calvet and Cohen (1978) and Morris (1981) suggested that these bipolar nebulae like M1-92,Hen 401,M2-9,M1-91,Mz-3 and also other objects mentioned above are in the early stages of the formation of planetary nebulae. Morris (1981) proposed that these bipolar nebulae resulted from non - corotating binary systems in which severe mass loss from the evolved component forms a disk in the equatorial plane around the system. Recent OH observations show that OH 19.2-1.0 and OH 26.5+0.6 are bipolar nebulae with characteristics similar to the objects described above. In this paper an analysis of the IRAS observations of ten bipolar nebulae described above is reported.

2. IRAS OBSERVATIONS

The IRAS fluxes of the bipolar nebulae mentioned above are obtained from the IRAS point source catalogue (Beichmann et.al.,1985). The IRAS fluxes for ten objects at 12μm,25μm,60μ m, and 100μm are listed in Table 1. The LRS 8 - 21μm spectra of these sources (Olnon and Raimond,1986) are also used in the present analysis.

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3.ANALYSIS

The LRS 8-21μm spectra of the objects listed in table 1 shows only continuum radiation by the dust. The flux maximum is around 25μm or 60μm. The 12μm to 100μm flux distribution clearly shows the large infrared emission from these objects. The 12μm to 100μm fluxes are integrated and are listed in Table 2. The temperatures T_d of the dust envelopes are derived from the far infrared flux distributions and colours. The dust temperatures (Table 2) are found to be in the range of 100 to 140K. For MWC 922 and OH 19.2-1.0 the dust temperature is 200K. The distances of these objects are taken from the literature and are listed in Table 2. The far infrared luminosities L_{IR} are derived from the integrated fluxes and using the distances. The L_{IR} values are found to range from $4.5\times10^4 L_\odot$ for Roberts 22 to $9.5\times10^2 L_\odot$ for OH 26.5+0.6. The mass M_d of the dust shells are estimated from the equation $M_d = 4/3$ (a d^2 $f_\nu \rho / Q_\nu B_\nu(T_d)$)), for details see Hilderbrand(1983). The masses of the dust envelopes for the ten objects are listed in Table 2, and are found to be in the same range as that found in planetary nebulae (Pottasch et.al.,1984). If the ratio of gas to dust mass is about 100 as it is in the interstellar medium then the total shell mass around Roberts 22 is 0.12M$_\odot$. The characteristics of the dust shells of these ten bipolar nebulae (Table 2) are found to be similar to the characteristics of dust shells around evolved stars and planetary nebulae. These ten objects are not associated with star forming regions and young stellar objects. The most likely explanation for the presence of dust shells around these ten objects with properties similar to that found in planetary nebulae is that they experienced severe mass loss in the recent past on their AGB stage of evolution. The mass loss rate from the central stars in these objects is of the order of 10^{-4} to 10^{-5} M$_\odot$ per year. The central stars in these objects appears to be evolving from the tip of AGB towards left in the HR diagram. These ten objects may be described as transition objects. Peimbert and Peimbert (1983) listed 29 planetary nebulae of Type I, most of them are bipolar. The far infrared (IRAS) characteristics of these Type I planetary nebulae are found to be similar to the objects described here (Table 2). The bipolar Type I planetary nebulae are found to be He and N rich. Some of the objects discussed here (M2-9, CRL 618, Mz-3) are also found to be N rich similar to Type I planetary nebulae. The ten objects (Tables 1 and 2) discussed here appear to be related to bipolar planetary nebulae. The bipolar disk geometry of Roberts 22 and other objects may be similar to that of M2-9. Aspin et al.,(1988) obtained high spatial resolution IR images of M2-9. They found a predominant disk-like structure 20″ in size stretching across the core region of M2-9. Peimbert and Peimbert (1983) suggest that the bipolarity is due to the high angular momentum of their progenitor stars and they estimate the progenitors masses to be in the range of $2<M/M_\odot<6$. However Morris (1981) proposed that these are young planetary nebulae in which the central objects are binaries and the bipolar structure and disk in the equatorial plane is the result of mass loss from the evolved components. The detection of central stars and their radial velocity variation study and also CNO abundance analysis may enable us to understand the evolutionary stage of these objects.

Table 1.Bipolar PN type objects similar to Roberts 22

	mag	Sp	IRAS fluxes (Jansky) 12μm	25μm	60μm	100μm
Roberts 22	16	A2Ie	200.0	1091.4	588.0	<271.6
M1-92	12	B1V	17.6	59.7	118.0	67.0
M2-9	13.7	B1e	50.6	110.2	123.1	74.8
OH231.8+4.2		M6I	19.0	226.3	548.3	292.1
M1-91	11.8	B0	3.9	8.3	12.0	9.4
MWC 922	12.5	Be	336.0	595.0	252.8	
Hen 401	13.5	Be	4.2	38.3	75.9	41.1
Mz-3	14.1	B0	89.1	340.5	276.4	111.2
OH19.2-1.0			14.8	32.7	20.0	
OH26.5+0.6			359.8	633.7	463.1	309.3

Table 2.Luminosities,Temperatures, and Masses of the Dust Envelopes

	d(kpc)	$F_{IR}(Wm^{-2})$	$L_{IR}(L_\odot)$	$T_d(K)$	$M_d(M_\odot)$
Roberts 22	2.5	2.3×10^{-10}	4.5×10^{4}	140	1.2×10^{-3}
M1-92	3.0	14.8×10^{-12}	4.2×10^{3}	100	4.3×10^{-4}
M2-9	3.0	22.8×10^{-12}	6.4×10^{3}	140	1.7×10^{-4}
OH231.8+4.2	1.3	58.6×10^{-12}	3.1×10^{3}	80	7.8×10^{-4}
M1-91	3.1	2.0×10^{-12}	6.0×10^{2}	130	0.2×10^{-4}
MWC 922	2.0	1.7×10^{-10}	2.1×10^{4}	200	1.4×10^{-4}
Hen 401	4.0	7.6×10^{-12}	3.8×10^{3}	100	3.9×10^{-4}
Mz-3	2.0	57.0×10^{-12}	7.1×10^{3}	140	1.9×10^{-4}
OH19.2-1.0	4.5	5.5×10^{-12}	3.5×10^{3}	200	2.2×10^{-5}
OH26.5+0.6	0.5	121.0×10^{-12}	9.5×10^{2}	150	0.2×10^{-4}

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