

Abstract

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Table 1. Observing Log

Facility	Date	Configuration	HPBW	PA	Observations
OVRO	May-2003 Sep-2003	C	9."8x7."0	72°	¹² CO (<i>J</i> =1-0), ¹³ CO (<i>J</i> =1-0), 2.6mm- continuum
SMA	Jul-2009, Sep-2010, Sep-2011	EX, VEX	0".7x0."5	67°	¹² CO (<i>J</i> =2-1), ¹³ CO (<i>J</i> =2-1), 1.3mm- continuum
IRAM 30m MRT	Jun-2007	-	~10".7	-	¹² CO (<i>J</i> =2-1)

Table 2. Line parameters

Transition	Rest Freq. (GHz)	V_{LSR} (km/s)	FWHM (km/s)	FWZI (km/s)	I _{peak} [1σ*] (Jy/beam)	Flux [1σ] (Jy*km/s)
¹² CO (<i>J</i> =2-1) ^a	230.5380000	-37±3	86±5	300	0.39 [0.03]	190 [10]
¹² CO (<i>J</i> =2-1) ^b	"	-33±2	125±5	300	1.36 [0.14]	182 [5]
¹³ CO (<i>J</i> =2-1) ^a	220.3986842	-33±3	50±3	150	0.16 [0.02]	27 [1]
¹² CO (<i>J</i> =1-0) ^c	115.2712018	-37±2	95±3	160	0.54 [0.04]	39 [2]
¹³ CO (<i>J</i> =1-0) ^c	110.2013543	-31±4	~10	~15	~0.12 [0.03]	4.5 [1.2]

a: SMA; b: IRAM 30m MRT ($S/T_{\text{A}}^* = 8$ Jy/K @ 230GHz); c: OVRO

* Spectral resolution $\Delta v \sim 2$ -2.6 km/s

IRAS 19374:

This peculiar, yet poorly studied object, was first suggested to be an OH/IR star evolving off the AGB phase by Kwok et al. (1987): its low IRAS color temperature ($\sim 200\text{K}$), the lack of variability, and the presence of an optical counterpart, indicate a detached dust envelope around an evolved star entering the PPN phase. Optical *HST* images show a $\sim 3'' \times 2''$ bipolar nebula (Ueta et al. 2000, see also Fig. X). In these images, we also find an elliptical extended halo ($R_{\text{halo}} \sim 3''$) with a brightness distribution suggestive of a mass-loss rate increasing with time. We have recently discovered $\text{H}\alpha$ emission with ~ 600 km/s-broad wings from the stellar vicinity, signaling on-going fast pAGB ejections; the line absorption spectrum of the central star is consistent with a B3-6 I classification (Sánchez Contreras et al. 2008). The chemistry of the envelope is not certain, but there is some evidence for the presence of the $9.7\mu\text{m}$ silicate feature in absorption and, therefore, for an O-rich chemistry (Lawrence et al. 1990). Near infrared H_2 line emission has been reported showing the presence of shocked molecular gas (Kelly et al. 2005). The distance to this object is estimated $d=11\text{kpc}$, which implies a total luminosity of $\sim 9 \times 10^4 L_{\odot}$ (SCS12).

SUMMARY OF MAIN OBSERVATIONAL RESULTS OF OUR SMA & OVRO CO MAPS:

We detected ^{12}CO and ^{13}CO 1-0 emission in IRAS19374 for the first time in our **OPACOS** survey (Sánchez Contreras & Sahai, submitted – see Fig. X). Our OPACOS data revealed a **broad CO emission line with a remarkable triangular shape**. This wing-dominated profile differs from those seen in most pPNe, with an intense line core at low velocity (with a parabolic, flat-topped, or horn-like shape) and, in some cases, weak broad wings. The CO 2-1 single-dish spectrum (more recently obtained with the IRAM 30m MRT) shows a similar wing-dominated profile with an even larger full velocity extent (**FWZI ~ 300 km/s**). The absence of a prominent narrow core both in the interferometric and single-dish profiles rules out interferometric flux losses of a presumably extended, slow nebular component as the cause of the atypical wing-dominated profile. The CO envelope is unresolved in our OPACOS maps (HPBW $\sim 9''.8 \times 7''$).

We have obtained sub-arcsec resolution CO emission maps at 230 GHz with the SMA in order to resolve spatially the envelope of IRAS 19374 (Figs. XX); we find CO emission over a ~ 300 km/s velocity range arising from a $2'' \times 2''$ molecular flow roughly elongated along the NS direction, i.e. collinear with the optical lobes. The p-v diagrams suggest an overall, yet rather **clumpy, hourglass morphology, with polar outflows** and a **dense toroidal structure expanding orthogonally to the lobes**. This type of morphology is observed in other PPNs, e.g. M2-56 and He3-1475 (Castro-Carrizo et al. 2002, Huggins et al. 2004). Our maps suggests that, as in M2-56 and He3-1475, the lobes of IRAS19374 may be incomplete, shell-like structures (i.e. "hollow"). The molecular outflow of IRAS 19374 has a subtle point-symmetry, which is also hinted in the optical *HST* images of the reflection nebulosity and that could point to an underlying precessing bipolar wind (Fig. XX).

Both molecular components, i.e. the lobes and the torus, are characterized by a **linear velocity gradient** (so-called Hubble-type outflow). In the lobes, the (projected) expansion velocity increases from V_{exp} -

$V_{\text{sys}} \sim 20$ km/s, near the center, up to $V_{\text{exp}} - V_{\text{sys}} \sim 150$ km/s at the tip of the South lobe. The lobes may have closed ends (where the axial velocity reaches its maximum), which would argue for the fast outflow not having broken out of the progenitor AGB CSE as yet. In the central, equatorial structure the (projected) expansion velocity reaches a maximum value of $V_{\text{exp}} - V_{\text{sys}} \sim 20$ km/s.

The Hubble-type outflow suggests constant-velocity, ballistic motions resulting from a sudden interaction between a bipolar post-AGB wind and the AGB CSE (see e.g. Alcolea et al. 2001). The radial expansion observed indicates a kinematical age for the outflow and the equatorial structure of $\sim 650-950 \tan(i)$ yr and $\sim 1500/\tan(i)$ yr, respectively, with i being the inclination of the polar axis with respect to the plane of the sky. Adopting a moderately low value of $i \approx 30^\circ$, suggested by the similar colors and surface brightness of the optical lobes, the dynamical age of the lobes would range between ~ 400 - 550 yr, whereas the age of the central torus would be ~ 2600 yr.

Our ^{13}CO 2-1 SMA maps confirms the presence of the dense torus, however, there are notable differences in the detailed structure of the low velocity component as revealed by the ^{13}CO and ^{12}CO 2-1 transitions (Fig. XX), indicating that $^{13}\text{CO}(J=2-1)$, due to its lower optical depth, is a better probe of the inner nebular regions.

Continuum emission at 1.3mm is detected from a central $\sim 2''$ -sized region maybe with a similar hourglass-distribution. The total 1.3mm flux integrated over the source is ~ 35 mJy.

The prominent wings and the lack of an intense, low-velocity line core in IRAS 19374 indicate that most or all of the molecular gas participates in the high-velocity flow. We estimate a total mass in the outflow of $\sim 1.2 \times (d/11 \text{ kpc})^2 M_{\odot}$ (from the optically thin $^{13}\text{CO} 1-0$ transition; [16]). Considering its large expansion speed (~ 150 km/s), we derive an unprecedentedly large value for the linear momentum carried by the outflow of $> 45 M_{\odot} \text{ km/s}$. To the best of our knowledge, there are only two other pPNe displaying similar wing dominated CO profiles, He3-1475 and IRAS 22036, although the mass and momentum of their fast outflows are much smaller than in IRAS 19374 [4,7]. For these two objects, high-angular resolution CO maps support the jet-envelope entrainment scenario since in both cases the CO wings arise in bipolar structures. It is likely that most of the molecular gas in the massive, slow AGB wind of IRAS 19374 has been affected by the shock interaction with post-AGB jets, but confirmation requires resolving its envelope.

PRELIMINARY ANALYSIS: physical parameters derived from CO maps

