IRAS 17423−1755 (HEN 3−1475) REVISITED: AN O-RICH HIGH-MASS POST-ASYMPTOTIC GIANT BRANCH STAR

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Abstract

The high-resolution ($R \sim 600$) Spitzer/IRS spectrum of the bipolar protoplanetary nebula (PN) IRAS 17423−1755 is presented in order to clarify the dominant chemistry (C-rich versus O-rich) of its circumstellar envelope as well as to constrain its evolutionary stage. The high-quality Spitzer/IRS spectrum shows weak 9.7 μm absorption from amorphous silicates. This confirms for the first time the O-rich nature of IRAS 17423−1755 in contradiction to a previous C-rich classification, which was based on the wrong identification of the strong 3.1 μm absorption feature seen in the Infrared Space Observatory (IRS) spectrum as due to acetylene ($C_2H_2$). The high-resolution Spitzer/IRS spectrum displays a complete lack of C-rich mid-IR features such as molecular absorption features (e.g., 13.7 μm $C_2H_2$, 14.0 μm HCN, etc.) or the classical polycyclic aromatic hydrocarbon infrared emission bands. Thus, the strong 3.1 μm absorption band toward IRAS 17423−1755 has to be identified as water ice. In addition, an [Ne ii] nebular emission line at 12.8 μm is clearly detected, indicating that the ionization of its central region may be already started. The spectral energy distribution in the infrared ($\sim 2$−200 μm) and other observational properties of IRAS 17423−1755 are discussed in comparison with the similar post-asymptotic giant branch (AGB) objects IRAS 19343+2926 and IRAS 17393−1755 in contradiction to a previous C-rich classification, which was based on the wrong identification of the strong 3.1 μm absorption feature seen in the Infrared Space Observatory (IRS) spectrum as due to acetylene ($C_2H_2$). The high-resolution Spitzer/IRS spectrum shows weak 9.7 μm absorption from amorphous silicates, such as olivines and pyroxenes, and crystalline silicate absorption from 10 to 45 μm (Sylvester et al. 1999; García-Hernández et al. 2007). At the end of the AGB phase, the crystalline silicate features become dominant and highly collimated ionized outflows like those detected in OH/IR stars or very young PN.

Key words: circumstellar matter – planetary nebulae: general – stars: AGB and post-AGB – stars: individual (IRAS 17423−1755)

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1. INTRODUCTION

IRAS 17423−1755 (Hen 3−1475) was first suggested by Parthasarathy & Pottasch (1989) as a possible member of the transition phase from the asymptotic giant branch (AGB) to the planetary nebula (PN) stage due to its unusual IRAS colors. The high values of the [N ii]/Hα ratios in the outflowing material detected by Riera et al. (1995) and the low luminosity deduced for the central star allowed them to confirm the classification of this object as an evolved star. Hubble Space Telescope (HST) and Very Large Array observations by Bobrowsky et al. (1995) showed the presence of both OH maser emission and highly collimated ionized outflows like those detected in OH/IR stars or very young PN.

HST images revealed a rich and complex morphological structure in the circumstellar material (see Section 4 for details). The outflow is collimated in bipolar jets along several condensations of shock-excited gas that extend about 11 arcsec. The lobes show expansion velocities of about 425 km s$^{-1}$ and a high velocity jet (~900 km s$^{-1}$) in the inner part of the lobes (Riera et al. 1995). The nebula displays a remarkable point symmetry that has been interpreted as due to the precession of a central binary system that undergoes episodic events of mass loss. Bobrowsky et al. (1995) proposed that the expanding shell has a torus-like structure where the OH emission originates in a high density region, where $H_2O$ is dissociated and further collimated in the observed jets. Additionally, Sánchez-Contreras & Sahai (2001) found evidences of ultrafast winds (up to 2300 km s$^{-1}$) highly collimated and located close to the central star which could be a relatively young post-AGB outflow not strongly altered by interaction with the AGB.

Stars at the end of the AGB phase are characterized by severe mass loss ($10^{-8}$ to $10^{-4}$ $M_\odot$ yr$^{-1}$), which results in the formation of circumstellar envelopes (Herwig 2005). The spherical symmetry of the envelopes of AGB stars is translated into a variety of shapes in the PN phase by a mechanism or mechanisms not as yet well understood. There is increasing evidence that at least in some instances the shaping starts at the end of the AGB phase (van Winckel 2003). IRAS 17423−1755 is a spectacular example that may represent a link between OH/IR stars with extreme outflows and highly bipolar PN.

The spectral energy distribution (SED) of extreme (e.g., highly embedded) OH/IR AGB stars is characterized by the presence of strong and broad amorphous silicate absorption features at 9.7 and 18 μm together with crystalline silicate absorption/emission features from 10 to 45 μm (Sylvester et al. 1999; García-Hernández et al. 2007). At the end of the AGB phase, the crystalline silicate features become dominant and can be observed in more evolved O-rich PN (Molster et al. 2001). Comparison of the Infrared Space Observatory (ISO) observations of O-rich dust shells surrounding evolved stars with laboratory data suggested the presence of several families of crystalline silicates, such as olivines and pyroxenes, and marked the beginning of an emerging discipline: the mineralogy of stellar and other astronomical (i.e., cometary) dust shells.
Additionally water-ice features at 3.1, 43, and 62 \( \mu m \) have been observed in heavily obscured and extremely bipolar sources such as the post-AGB star IRAS 19343+2926 (or M1–92; see, e.g., Dijkstra et al. 2006, and references therein).

Gauba & Parthasarathy (2004) studied the ISO spectra of seven hot post-AGB stars including IRAS 17423–1755. DUSTY models (Ivezić & Elitzur 1997) were fitted to optical, near- and far-infrared (IRAS and ISO) photometry in order to reconstruct the SEDs and to derive physical parameters such as dust temperatures, mass-loss rates, angular radii, and the inner boundary of the dust envelopes. For the particular case of IRAS 17423–1755 they considered a combination of silicates and carbon in the circumstellar environment. They reported the presence of a broad absorption feature at 3.1 \( \mu m \) that they identified as due to the presence of \( \text{C}_{2} \text{H}_{2} \) and/or HCN in the circumstellar envelope. This identification led these authors to infer a C-rich chemistry for the shell. More recently, Cerrigone et al. (2009) presented observations of a sample of 26 hot post-AGB stars with the Infrared Array Camera and the Infrared Spectrograph (IRS) on board the Spitzer Space Telescope. These observations were analyzed together with Two Micron All Sky Survey, IRAS, and radio centimeter data in order to model the SEDs of the targets. Cerrigone et al. (2009) classified IRAS 17423–1755 as a C-rich star on the basis of the Gauba & Parthasarathy (2004) report of the \( \text{C}_{2} \text{H}_{2} \) feature at 3.1 \( \mu m \) and in the absence of a strong 9.7 \( \mu m \) amorphous silicate absorption/emission feature in their low-resolution (\( R \sim 64–128 \)) Spitzer spectrum. However, they pointed out that the expected polycyclic aromatic hydrocarbon (PAH) features in the 5–12 \( \mu m \) region are not detected. It is to be noted here that weak and narrow molecular absorptions from C-based molecules such as 13.7 \( \mu m \) \( \text{C}_{2} \text{H}_{2} \), 14.0 \( \mu m \) HCN, etc., are difficult to detect at the low resolution of their Spitzer spectrum. The detection of these C-rich molecular absorptions—typical of C-rich AGB/post-AGB stars—requires in most of the cases higher resolution observations such as those provided by the high-resolution modes of Spitzer (\( R \sim 600 \)) and ISO (\( R \sim 1000 \)) (see, e.g., Cernicharo et al. 1999, 2001; García-Hernández et al. 2009).

The controversial origin of the mid- to far-IR features in IRAS 17423–1755 merits a re-analysis of the dust features observed in the high-resolution and higher quality Spitzer spectrum. In Section 2 we present the new Spitzer observations together with the construction of the overall SED of the nebula as observed by both Spitzer and ISO, while in Section 3 the evidence for an O-rich chemistry is analyzed and discussed. The evolutionary stage of IRAS 17423–1755 is discussed, including our new results, in Section 4 while a summary of our main conclusions is presented in Section 5.

2. SPITZER AND ISO OBSERVATIONS

OF IRAS 17423–1755

High-resolution (\( R \sim 600 \)) Spitzer/IRS spectra of IRAS 17423–1755 are now available in the Spitzer public database. Short–high (SH: 9.9–19.6 \( \mu m \)) and long–high (LH: 18.7–37.2 \( \mu m \)) observations were obtained on 2009 April 21 under the General Observer Program 50777 (PI: B. McCollum). A typical signal-to-noise ratio (S/N) higher than 50 was easily reached by using just three cycles of 6 s for both SH and LH modules. However, the S/N is much lower for wavelengths longer than 34 \( \mu m \)—the red end of the LH module that is affected by a strong noise level. The post-bcd products (one spectrum for each nod position) automatically reduced by the IRS Custom Extractor (SPIRE) were retrieved from the Spitzer database.

The automatic data reduction includes the extraction from the two-dimensional images as well as the wavelength and flux calibration. The Spitzer-contributed software SMART (Higdon et al. 2004) was used for cleaning residual bad pixels, spurious jumps and glitches, and for smoothing and merging. The short–low (SL: 5.2–14.5 \( \mu m \)) Spitzer spectrum reported by Cerrigone et al. (2009) was also retrieved from the Spitzer database. We found a good match (\( \leq 5\% \)) between the SL and SH module spectra. However, the absolute flux level of the LH module spectra was found to be \( \sim 8\% \) higher than the SH module spectra. Thus, we scaled the LH observations to the SH ones in order to obtain the final high-resolution Spitzer spectrum of IRAS 17423–1755. The good match between the Spitzer/IRS SL and the SH spectra is illustrated in Figure 1. For comparison, we also retrieved from the Spitzer database the high-resolution Spitzer observations of the similar post-AGB star IRAS 19343+2926 and IRAS 17395–2727 (an OH/IR massive post-AGB already reported by García-Hernández et al. 2007).

The full range ISO SWS+LWS spectrum of IRAS 17423–1755 was obtained in 1997 March as part of the open-time program PGARCIA.PN on spectroscopy of proto-PN candidates. Both SWS and LWS spectra were taken in the full scan AOT1 mode (de Graauw et al. 1996) at speed 1. The data were processed using the standard Interactive Analysis Software, version 7.0 of the SWS and LWS offline processing system at the Max Planck Institute for Extraterrestrial Astronomy (Garching, Germany); see García-Lario et al. (1999) for more details on the reduction procedure. All detector signals were inspected for spurious features, which were removed. No fringes were seen in the ISO spectrum of this source. There is good agreement between our SWS spectrum and IRAS low-resolution overlap region, and a good match between the SWS and LWS spectra. The 3.1 \( \mu m \) absorption band can be clearly observed in SWS AOT Band 1D. No firm conclusions can be drawn concerning...
The overall SEDs of IRAS 17423−1755 and IRAS 19343+2926 peak between 40 and 60 μm. Notably, the absorption feature in the 2.5−3.5 μm region appears strong in both objects, together with [C II] in emission at 158 μm; however, this latter feature might be Galactic residual background emission.

The ~2−180 μm SEDs in Figure 2 display a very cold bimodal continuum that can be interpreted in terms of thermal emission from the dust. Obviously, it would correspond to several wavelength-dependent dust emissivities with a certain range of dust temperatures, but we found that two main components of the nebular dust, cold (strong) and hot (weaker), could roughly reproduce the general trend of the observed overall energy distribution. We performed a multiple blackbody fitting using the IRAF routine NLFIT on the Fν over λ spectrum and obtained blackbody temperatures of 120 K and 965 K for IRAS 17423−1755 (in agreement with the values reported in Gauba & Parthasarathy 2004) and temperatures of 120 K and 965 K in the case of IRAS 17423−1755. The fitted blackbody curves are shown in the Fν over λ spectra of Figure 2, where we also detail the fitting in the region of the 3.1 μm absorption feature.

Bunzel et al. (2009) have recently reported difficulties in modeling the SEDs of heavily obscured O-rich post-AGB stars by using a more sophisticated radiation transfer code for dusty environments such as DUSTY. They needed to add amorphous carbon dust in their DUSTY models in order to reproduce both the observed red continua and the apparently weak 10 μm amorphous silicate absorption. It is to be noted here that the inclusion of amorphous carbon grains in the DUSTY models of O-rich post-AGB stars does not necessarily mean that these sources are C-rich; their infrared spectra show O-rich dust features only. Other more unusual O-rich dust species with optical properties similar to those of the amorphous carbon grains could be present in the circumstellar shells of heavily obscured O-rich post-AGB stars (see Section 4), also giving a good fit to the observed SEDs of these stars (R. Szczerba 2009, private communication). These difficulties prevent us from proceeding further with this modeling, as the thermal continuum around 3 μm was found to provide an adequate reference for the optical depth of the observed feature and we are mainly interested in the analysis of the dust features present in the new high-resolution Spitzer spectrum.

3. DISCUSSION

3.1. O-rich Chemistry

The most interesting and well-defined feature in the ISO spectrum of IRAS 17423−1755 is a clear absorption band at 3.1 μm, which we identify for the first time as water ice (see below) present in the dust grains of the circumstellar material. Similar detections are not very numerous, the comparison object being IRAS 19343+2926, a bipolar post-AGB star with an O-rich composition, another case that has also been observed with ISO. The identification of this 3.1 μm absorption feature as C2H2 has been confirmed by Bunzel et al. (2009). However, the new high-resolution Spitzer/IRS spectrum confirms. Figure 3 displays the SED of IRAS 17423−1755 from 2 μm to ~16 μm together with the comparison O-rich post-AGB stars IRAS 19343+2926 and IRAS 17393−2727. No other feature characteristic of a C-rich chemistry (e.g., SiC, PAHs, C2H2, HCN) in the circumstellar environment was found. The comparison object being IRAS 19343+2926 is of much higher quality than that of IRAS 19343+2926 was found to provide an adequate reference for the optical depth of the observed feature.

IRAS 17423 is a clear absorption band at 3.1 μm absorption feature as C2H2. Moreover, the spectrum of IRAS 17423 shows a strong absorption feature at ~2.1 μm, which we identify for the first time as water ice (see below) present in the dust grains of the circumstellar material. Similar detections are not very numerous, the comparison object being IRAS 19343+2926, a bipolar post-AGB star with an O-rich composition, another case that has also been observed with ISO. The identification of this 3.1 μm absorption feature as C2H2 has been confirmed by Bunzel et al. (2009). However, the new high-resolution Spitzer/IRS spectrum confirms.
Figure 3. Spitzer/IRS and ISO SWS spectra from ~2 to 16 μm for IRAS 17423−1755 in comparison with those of the O-rich post-AGB stars IRAS 19343+2926 and IRAS 17393−2727. This figure illustrates the presence of the broad 9.7 μm absorption from amorphous silicates (O-rich) and the absence of C2H2 absorption at 13.7 μm. [Ne ii] 12.8 μm nebular emission is clearly detected in the three sources.

(A color version of this figure is available in the online journal.)

envelope can be found in the observed Spitzer spectrum. In particular, there is no indication of the presence of C2H2 absorption at 13.7 μm and the key point here is that the C2H2 rotational lines at ~3 and 14 μm are of similar strength (~20% from the continuum; see, e.g., Cernicharo et al. 1999). Thus, if the 3.1 μm absorption feature is due to C2H2, then the C2H2 13.7 μm feature should be detected in the high-resolution Spitzer spectrum presented here. The non-detection of this feature, or even the other small hydrocarbons detected in C-rich post-AGB stars (Cernicharo et al. 1999, 2001) supports our identification of the 3.1 μm absorption band with water ice.

Spitzer/IRS SL and SH spectra of IRAS 17423−1755 reveal for the first time a mid-IR feature that was not evident in the low S/N ISO spectrum (Kraemer et al. 2002; Gauba & Parthasarathy 2004) and that was not recognized by Cerrigone et al. (2009) in their IRS/SL spectrum. A weak and broad 9.7 μm absorption from amorphous silicates (O-rich) is present. This is shown in Figure 3, in comparison with the other well-known O-rich post-AGB stars IRAS 17393−2727 and IRAS 19343+2926.

García-Hernández et al. (2007) discussed the presence of crystalline silicates in the Spitzer/IRS spectrum of IRAS 17393−2727. They reported the presence of several weak crystalline silicate emission features in the 27−31 μm region and crystalline silicate absorption features at shorter wavelengths. In particular, an absorption feature at 15.4 μm can be clearly observed in the IRS spectrum of this star presented in Figure 3. Such crystalline silicate absorption/emission features cannot be claimed for definitely in either IRAS 17423−1755 or IRAS 19343+2926 at the S/N level of our Spitzer/IRS spectra. It is worth noticing here that these weak crystalline silicate features have been observed in the circumstellar envelopes of O-rich evolved stars with a variety of strengths and at slightly different wavelengths from source to source, depending on the specific chemical composition and the size and density of the dust grains in the circumstellar envelope (García-Hernández et al. 2007).

Our identification at 3.1 μm of water ice and the weak 9.7 μm amorphous silicates absorption permit us to infer for the first time an O-rich chemistry for the circumstellar envelope around IRAS 17423−1755. Figure 3 shows that a notable similarity exists between the infrared spectra of the O-rich post-AGB star IRAS 19343+2926 and that of IRAS 17423−1755. In addition, [Ne ii] nebular emission at 12.8 μm is also detected for the three objects shown in this figure, suggesting that the ionization of the circumstellar material may have already started in these evolved stars.

3.2. Water Ice in Highly Embedded Evolved Stars

The conditions for condensation and properties of amorphous and crystalline H2O ice in astrophysical environments have been extensively reviewed by several authors (Leger et al. 1979, 1983; Baratta et al. 1991; Kouchi et al. 1994; Smith et al. 1994). Different forms of water ice can be observed, depending mainly on temperature, pressure, and the mechanisms of deposition. For typical low pressure conditions present in the circumstellar envelopes, temperatures higher than 150–170 K produce hexagonal ice, which remains stable during further cooling. If deposition takes place at lower temperatures (between 110 and 130 K) cubic ice is formed, while at temperatures lower than 100–130 K the resulting ice is amorphous (Baratta et al. 1991; Kouchi et al. 1994).

In the circumstellar envelopes of evolved stars, water ice can condense forming icy mantles on dust grains which have previously condensed while the gas cooled down in the expanding envelopes. In O-rich envelopes, all the carbon atoms are thought to be locked in CO molecules and the remaining O atoms are supposed to form H2O aggregates. Determining the occurrence and characterization of water-ice features is interesting because ice in these mantles can provide important diagnostics of the physical conditions in circumstellar envelopes. Water ice has been observed in a significant sample of AGB stars—in particular in OH/IR stars—some post-AGB stars and a few PN (Onomot et al. 1990; Eiroa & Hodapp 1989; Hoogzaad et al. 2002; Molster et al. 2001). The specific conditions for the formation of water ice in circumstellar envelopes around evolved stars have been discussed and modeled by Dijkstra et al. (2003, 2006), who also studied the trends that can be observed in the 3, 43, and 62 μm water-ice features during the stellar evolution from the AGB to the PN phase.

According to Dijkstra et al. (2006) it continues to be a puzzle why some stars form water ice and not others. One clue these authors found might be the fact that the strength of the 3, 43, and 62 μm water-ice features increases with the increasing initial mass of the star. Their model calculations suggest that water-ice features will be too weak to be detectable for stars with zero age main sequence (ZAMS) masses lower than 5 M⊙; the water-ice features completely disappear for initial masses lower than ~3 M⊙. A high mass-loss rate also favors the detectability of the water-ice features, as well as large values of the mass-loss rate to luminosity ratio. The absence of a strong interstellar UV radiation field also preserves ices, as well as the presence of a high density region that can provide shielding from an energetic radiation field.

Both crystalline and amorphous water ice can form in circumstellar envelopes. The models developed by Dijkstra et al. (2006) show that the shape of the spectral features is very sensitive to the type of water ice aggregate formed. The 3.1 μm crystalline water ice absorption feature is characterized by a sharp core with two equally strong shoulders. On the other hand, the amorphous water ice absorption feature is broader, with no substructures, and displaced to shorter wavelengths. In the 30−100 μm region, crystalline water ice shows two prominent and very broad emission features near 43 and 62 μm.
In the case of amorphous water ice, these latter features are undetectable because they are broad and show almost no contrast with the dust continuum.

Figure 4 details the 3.1 μm water ice band in IRAS 17423–1755 and in IRAS 19343+2926. In both cases, the band presents a sharp profile and shows the characteristic shoulders on both sides of the central core, indicating that most of the water ice formed must be crystalline. This is demonstrated by the good match that can be appreciated among the observed profiles and the model displayed in the figure, calculated for crystalline water ice deposited at a dust excitation temperature of 150 K by Smith et al. (1989).

Additionally, the ISO spectrum of IRAS 19343+2926 shows the presence of the water ice bands at 62 and 43 μm (Dijkstra et al. 2006), confirming the crystalline nature of the water ice in this star. The presence of these latter features cannot be excluded in the case of IRAS 17423–1755 because of the poor quality of the ISO LWS spectrum (see Figure 2). A much higher S/N spectrum would be needed in order to confirm/discard the detection of the crystalline water ice features at the longer wavelengths. The water ice features are providing us with valuable information for interpreting the precise evolutionary stage of these nebulae. This point will be addressed in Section 4 together with the analysis of other observational properties such as the nebular morphology and the presence of amorphous silicates.

4. EVOLUTIONARY STAGE

The available HST optical images for IRAS 17423–1755 (Bobrowsky et al. 1995) and IRAS 19343+2926 (Trammell & Goodrich 1996) were retrieved from the HST archive in order to compare the morphological properties of both objects. These optical images are presented in Figure 5, together with the HST image of IRAS 17393–2727 (unpublished), showing that strong and highly collimated bipolar outflows are observed in the three objects. Note that bipolar morphologies are mainly found among Type I PNe, which are expected to be the descendants of the evolution of the more massive AGB/post-AGB stars (Corradi & Schwarz 1995).

The models by Dijkstra et al. (2006) discussed in Section 3.2 have shown that the conditions for the formation and prevalence of crystalline water ices, like those observed in IRAS 17423–1755 and IRAS 19343+2926, would imply high initial masses (at least higher than ~3 M☉) for the central star and the probable presence of high density structures such as a dusty disk or torus, which could completely obscure the central star in the optical/near-IR wavelength range. The existence of such dusty disk/torus structures is confirmed in the optical images of both objects. Garcia-Hernández et al. (2007) have proposed that heavily obscured high-mass precursors of PN like IRAS 17393–2727 may be already developing strong bipolar outflows, and it is likely that a thick circumstellar disk/torus—where the crystallization of water ice could take place—is surrounding the central post-AGB star. The presence of a highly collimated bipolar outflow as well as a thick circumstellar disk/torus that completely obscures the central source in IRAS 17393–2727 is now confirmed by the available HST images shown in Figure 5.

Sylvester et al. (1999) used the ISO spectra of a sample of OH/IR stars to analyze the IR characteristics of their circumstellar dust. They found that the optical depth of the ~10 and 18 μm amorphous silicate features increases with increasing mass-loss rate during the AGB. The same results were found by Dijkstra et al. (2006), who modeled the evolution of the 2–200 μm SED for a 5 M☉ (ZAMS) star evolving from the early AGB until the early PN stage. At the end of the AGB, the circumstellar envelope detaches from the star, becoming optically thin and causing the amorphous silicate features to disappear. This infrared evolutionary sequence from the AGB to the PN stage has been observationally confirmed by García-Hernández et al. (2007) using Spitzer spectra of massive O-rich AGB/post-AGB stars.

Regarding the evolutionary state of IRAS 174231755, it is likely that this star is more evolved than IRAS 19343+2926 because the amorphous silicate absorption and the water ice band observed in IRAS 17423–1755 are weaker than those seen in IRAS 19343+2926 (see Figure 4). IRAS 17393–2727 could be the least evolved object of the three because it has optical/near-IR counterpart (the central star is not detected even in the K band). However, in the case of IRAS 19343+2926 and IRAS 17423–1755, the central star has already reappeared in the optical/near-IR range. The presence of [Ne ii] nebular emission could provide evidence on the onset of the circumstellar envelope ionization, although shock excitation in the high-velocity outflows cannot be excluded.

The SED of IRAS 17423–1755 is similar to those of extreme OH/IR AGB stars, which exhibit absorption features from amorphous silicates together with crystalline silicate features that alternate between emission and absorption depending on the specific physical and chemical properties of the circumstellar dust grains (Sylvester et al. 1999). We think that the presence of crystalline silicates in the 13–35 μm region in IRAS 17423–1755...
and IRAS 19343+2926 cannot be excluded but that higher S/N spectra would be needed in order to confirm or discard such a presence.

In summary, the bipolar morphology, the detection of OH maser emission and crystalline water ice as well as the 9.7 μm absorption from amorphous silicates present in the Spitzer spectrum indicate that IRAS 17423−1755 is a massive O-rich post-AGB star similar to IRAS 19343+2926 and IRAS 17393−2727. The three sources represent a link between massive OH/IR AGB stars and bipolar type I PN.

5. CONCLUSIONS

An O-rich chemistry for the circumstellar envelope around the post-AGB object IRAS 17423−1755 is confirmed, despite a previous classification as C-rich. This result is based on the detection of a weak and broad 9.7 μm amorphous silicate absorption in the high-resolution Spitzer/IRS spectrum. The complete lack of C-rich mid-IR features (in particular C2H2 at 13.7 μm) supports our identification of the strong 3.1 μm absorption band seen in the ISO spectrum as due to water ice as well as our O-rich classification for IRAS 17423−1755.

IRAS 17423−1755, IRAS 19343+2926, and IRAS 17393−2727 present clear evidences of the presence of a circumstellar disk or torus, where the conditions would be very similar to those found in less evolved and more embedded OH/IR stars. A recent strong mass-loss event has been reported in the case of IRAS 19343+2926 (Alcolea et al. 2007), which would favor this scenario. Water ice and crystalline silicates would preferentially form in the outer region of the inner torus, where low temperature conditions and shielding from the central star would allow a favorable rate of crystallization to take place. Both in IRAS 17423−1755 and IRAS 19343+2926, the ice band at 3.1 μm is sharp and presents substructures, and comparison with models of water ice growth around evolved stars (Smith et al. 1989; Dijkstra et al. 2006) allows us to confirm that the ice is mostly in a crystalline state.

The morphological properties, detection of OH maser emission, and the Spitzer/IRS spectra observed in IRAS 17423−1755 are similar to those of the O-rich post-AGB stars IRAS 19343+2926 and IRAS 17393−2727, allowing us to interpret the evolutionary stage of IRAS 17423−1755 as belonging to an intermediate stage between those OH/IR stars with extreme outflows and highly bipolar type I PN.

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