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Infrared OH absorption lines in 1612 MHz OH maser sources

J. H. He[1,2], **P. S. Chen**[1], **R. Szczerba**[3] **and A. M. Sobolev**[4]

[1]National Astronomical Observatories/Yunnan Observatory, CAS, PR China
[2]Academia Sinica, Institute of Astronomy and Astrophysics, Taiwan, China.
email: jhhe@asiaa.sinica.edu.tw
[3]N. Copernicus Astronomical Center, Rabianska 8, 87-100 Torun, Poland
[4]Astronomical Observatory, Ural State University, Lenin Street 51, Ekaterinburg, Russia

Abstract. ISO mid-infrared absorption data helps to distinguish between radiative and collisional pumping mechanisms in 1612 MHz OH masers in various environments. Archive data of OH absorption at 34.6 and 53.3 μm shows different behavior and different pumping rates for different types of maser sources.

1. Mid-Infrared absorption in 1612 MHz OH masers

Mid-infrared spectroscopy by the Infrared Space Observatory (ISO) first provided a way to directly distinguish between infrared pumping and collisional pumping in OH masers in various astrophysical environments using the presence of IR absorption lines.

The ISO archive spectra for all known Galactic OH 1612 MHz masers have been searches for OH related absorption. Absorption at 34.6 μm is detected by the ISO Short Wavelength Spectrometer (SWS) in only 5 sources (out of 87) while at 53.3 μm absorption is detected by the ISO Long wavelength Spectrometer (LWS) in 11 sources (out of 48). The non-detection of the two lines in most of the sources is due to the low spectral resolution and/or sensitivity of the ISO instruments. However, we found respectively 16 and 7 sources with spectra of good enough quality that do not show the 34.6 and 53.3 μm absorption lines (He *et al.* 2005, He & Chen 2004) possibly due to clumpy shell or limb-filling emission.

The spectra of the detected lines are reproduced in Fig. 1 (He *et al.* 2005, He & Chen 2004). Panel A shows the five 34.6 μm line profiles while Panels B and C present the 53.3 μm line profiles of the 11 sources. The spectra of the 53.3 μm spectra in panels B and C are grouped according to the following classification: *RaBe* – redshifted absorption and blueshifted infilling emission, *Asymm* – asymmetrical profile, *GCMega* – symmetrical profile of GC or megamasers, and *BaRe* – blueshifted absorption and redshifted infilling emission. The weak infilling emission features are found to be ubiquitous: blueshifted *RaBe* infilling in stellar OH masers, and redshifted *Asymm* or *BaRe* infilling in interstellar OH masers. Infilling is not present in the symmetric *GCMega* profiles of GC and megamaser sources. The shifted infilling emission is possibly due to emission in only one of the 53.3 μm doublet components. The alternative of a velocity shift of about 560 km/s ($\approx 0.1\,\mu$m) from the nominal line center is unreasonable in such sources. However, it is not clear how such doublet asymmetry arises in the two types of OH masers. The OH maser pumping routes tracing technique developed by M. Gray (2007, these proceedings) may provide an answer.

The exact pump rate may be defined as: *the integrated photon flux of the blue+red OH maser peaks divided by the integrated 35+53 μm absorption photon flux.* The pump rate was calculated for six sources with both infrared OH absorption lines (at least tentatively)

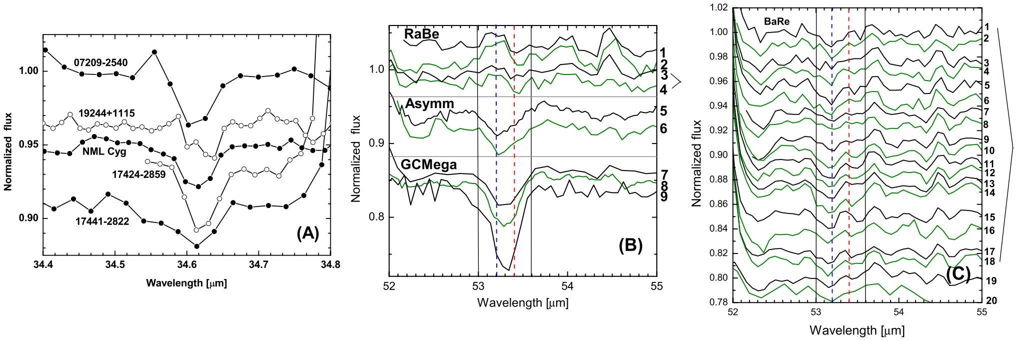

Figure 1. Infrared OH absorption line spectra at 34.6 μm (A) and 53.3 μm (B & C). The classification *RaBe*, *Asymm*, *GCMega*, *BaRe* is explained in the text. The vertical lines mark the range of the line while the two dashed lines mark the blue and red shifted components respectively. IRAS names associated with the spectra: Panel B (1) 03507+1115 (AGB), (2) 07209-2540 (RSG), (3,4) NML Cyg (RSG), (5) 17424-2852 (H II), (6) 17430-2848 (cluster), (7) 17424-2859 (GC), (8) 17441-2822 (GC), (9) Arp 220 (Galaxy); Panel C (1-18) 20255+3712 (H II), (19) 06053-0622 (H II), (20) 17574-2403 (H II).

detected. The pump rates of three stellar OH maser sources (two red supergiants 07209-2540 and NML Cyg and one yellow hypergiant 19244+1115) are very similar (0.079, 0.041 and 0.054, respectively), while the two GC sources (17424 – 2859 and 17441 – 2822) have much smaller rates (3.56×10^{-6} and 1.56×10^{-5}, respectively). The pump rate of the interacting galaxy Arp 220 of 0.32 is much larger than any of the considered sources. The similar pump rates of stellar masers suggest radiative pumping of the stellar masers, since the infrared absorption is proportional to maser emission (Elitzur *et al.* 1976). The varying (small) pump rate of GC sources may be due to interstellar absorption by non-maser OH cloudlets (He 2005). The large pump rate of Arp 220 may result from strong beaming (A.M. Sobolev and W.A. Baan – private communication).

2. Conclusions

Improved mid-infrared spectrometry is needed to resolve the weak 34.6 and 53.3 μm lines in many galactic OH 1612 MHz maser sources. A limited sample of detections shows ubiquitous infilling emission in the 53.3 μm absorption line profiles of galactic OH masers with blueshifted features in stellar masers and redshifted features in interstellar OH masers. Infilling emission features can be interpreted as emission of a single 53.3 μm doublet component. Similar pump rates among stellar OH 1612 MHz masers demonstrate an effective radiative pumping mechanism. Observational and theoretical studies are needed to confirm/interpret the weak line features and *true* non-detection sources.

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