INTERSTELLAR H₂O MASERS. A TRACER OF GALACTIC SPIRAL STRUCTURE?

(Letter to the Editor)

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Abstract. The large-scale distribution of interstellar H₂O masers is given in this paper. Present results show that H₂O masers can trace galactic spiral structure, and we also briefly discuss how to obtain a more accurate distribution of H₂O masers from future observations.

1. Introduction

Studying galactic spiral structure is always an emphasis in astronomy. A powerful means is observations at radiofrequencies. Besides H I, H II regions and CO, there are mainly H₂CO line (Downes et al., 1980) and anomalous 1720 MHz OH emission (Turner, 1983) among others that have also been investigated as tracers of spiral arms. Despite a lot of effort, however, a clear picture of spiral structure is still not available because of various difficulties in researches (cf. Liszt, 1985). Obviously only after we obtain sufficient observations and combine results of all tracers, an exact understanding of spiral pattern can be possible.

A good approach to this problem is to get more information on disk structure from distributions of some astronomical objects other than normal tracers. With the advance of radio observing techniques, interstellar OH and H₂O masers near star-forming regions (SFR) were discovered more than two decades ago and have grown rapidly in number (for a review see Reid and Moran, 1988). The importance of these strong emission sources to spiral structure study is not clear presently. In this paper we make an effort toward this direction by studying large-scale distribution of H₂O masers. It is generally believed that H₂O masers exist in the extremely early stage of star formation (e.g., Genzel and Downes, 1977; Habing and Israel, 1979) when associated young stars are difficult to detect by other means, and H₂O masers is probably the most prominent indication of OB stars right after formation. Because of its special status in SFR H₂O masers give unique information about large-scale distribution of star-forming regions. And if it can trace spiral arms well, the significance is obvious. Although most H₂O masers were detected near SFR and an unbiased survey is still lacking, it is reasonable to believe that no abundant masers reside far away from SFR because of pumping requirement. Thus present observational data will adequately tell us an approximate
case of H$_2$O masers distribution and permit us to analyse the prospect of using H$_2$O masers to trace spiral pattern.

2. Data Collection

Our work bases on data of 385 interstellar H$_2$O masers, 359 of which are from Ling et al. (1989) and the rest are supplemented from Henkel et al. (1986) and Caswell et al. (1989). Thus, in fact, we include all the observational data we had known before 1990. We adopt spectral peak velocities ($V_p$) to represent radial velocities of H$_2$O masers. The influence of this adoption to our results will be discussed in Section 3. We use all distance data available to us, in which 90 are from Genzel and Downes (1977, 1979), 30 from Braz and Epchtein (1983), 47 from Caswell et al. (1983a, 1989), Forster and Caswell (1989), Henkel et al. (1986), and Wilking and Clausen (1987). For 15 sources the distances of their nearby H II regions are adopted (Caswell et al., 1975, 1983a, b; Caswell and Haynes, 1987; Fich and Blitz, 1984; Radhakrishnan et al., 1972). Other 38 sources distances are calculated from Schmidt model (Schmidt, 1965). In solving distance ambiguity, we either adopt the criterion that the distances to the galactic plane should not exceed 300 pc, or refer to Caswell et al.’s (1975, 1983a, b) results.

3. Results and Discussions

Figure 1(a) gives the longitude-peak velocity distribution of interstellar H$_2$O masers. In the first quadrant, the local-Sagittarius and Sagittarius–Scutum interarm gaps can be seen, respectively, around $V = 40$ km s$^{-1}$, $l = 55^\circ$ and $V = 80$ km s$^{-1}$, $l = 35^\circ$. We suppose that a few sources reside in the gaps because of interference from their intrinsic motions (see next paragraph). An interesting pattern also appears in the third quadrant of Figure 1(a). Figure 1(a) is similar to that of H II regions (see Bash and Turek, 1983), especially in the southern hemisphere, and it shows to be more patterned as a whole than $l-V$ diagrams of CO (see Cohen et al., 1980) and H$_2$CO (Downes et al., 1980).

In order to investigate the influence of H$_2$O masers’ intrinsic motions to $l-V_p$ distribution, for those sources with known distances we calculate their systemic radial velocities (hereafter $V_r$) from Schmidt’s model. These sources’ $l-V_p$ distribution is given in Figure 1(b). Sources with galactocentric distances less than 4 kpc are not included. If $|V_p - V_r| > 15$ km s$^{-1}$, the source is represented by a circle. The solid and dashed lines indicate terminal velocities and locations of material in 4 kpc ring, respectively, derived from Schmidt’s model. Those sources that locate beyond terminal velocity curves or within 4 kpc ring generally have $|V_p - V_r|$ larger than 15 km s$^{-1}$. The ‘circle’ sources should have violent intrinsic motions, but their influence is not significant. It can be seen from Figure 1(b) that only a small portion of H$_2$O masers has larger velocity differences. A more reliable spectral velocity should be looked for instead of $V_p$ for these sources in future work (see below). If ‘circle’ sources are ignored, the local-Sagittarius interarm gap appears more apparent and Figure 1(b) displays a more clear pattern. All these facts indicate that $l-V$ diagram of H$_2$O masers can be as meaningful as that of