Masters Projects in Radio Astronomy:

Understanding the behaviour of methanol masers around newly-formed stars

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Outline

Stars form deep inside clouds of gas and dust, a process observable only at infrared and radio wavelengths. One signature of the formation of a star is the presence of stimulated microwave emission (masers) from molecules being excited by the infrared radiation. Hydroxyl and methanol molecules are excited in the this way near protostars that will become visible as high-mass O and early B stars. Water masers also appear, but they are collisionally excited and can be seen in outflows from much lower mass stars.

The most widespread and brightest of the methanol masers were only discovered quite recently - at 12.2 GHz in 1987 by Batrla et al. and at 6.7 GHz in 1991 by Menten. Hundreds have been discovered in the Milky Way (many using the 26-m Hartbeesthoek radio telescope), and understanding their properties and what they can tell us about the environment of high mass protostars is still in its infancy. As part of this research, a large set of 6.7-GHz masers and a smaller subset of 12.2-GHz masers were monitored for several years using the Hartebeesthoek telescope. These have revealed types of behaviour not previously known in star-forming regions, notably quasi-periodic and periodic variations on timescales of months to years (Goedhart, Gaylard & van der Walt 2003; Goedhart 2004). Data obtained to 2003 April have been reduced and studied, but monitoring of the most interesting of these masers continues at HartRAO, using the new high performance spectrometer.

The extension of this research provides opportunities for research work towards an MSc. Here are some possibilities:

- Do the new data acquired since 2003 April confirm the interpretations of the earlier data?
- What are the statistical characteristics of the variability, such as in the rapidly varying, aperiodic masers (MacLeod & Gaylard 1996)?
- Different types of variation imply different underlying causes: for aperiodic variations it could be turbulence or passing clumps of hot gas; for quasi-periodic variations density waves in an accretion disc around the protostar might be the cause; the strict regularity of periodic variations strongly constrains possibilities, and orbit motion of a binary system seems most plausible. These possibilities all need investigation.
- We need a better understanding of how the methanol masers work and respond to their environment - e.g. how do we explain the differences in characteristics and behaviour of the 12.2- and 6.7-GHz masers in the same object?

References

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MacLeod G C & Gaylard M J, 1996, MNRAS, 280, 868
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