Radioactive Molecules in Space

A. A. Breier, T. F. Giesen ,

Astrophysical observations of radioactive isotopes, like ^{26}Al, ^{44}Ti, or ^{60}Fe, provide insight into the nucleosynthesis of stellar cores[1]. The detection of characteristic γ-photons which are released during radioactive decay are used to map their spatial distribution on large scale[2]. In general, the assignment to certain stellar objects fails due to limited sensitivity, exceptions are the nearby supernovae remnants *Cas A*[3] and *SN1987A*[4] for which the radioactive decay of ^{44}Ti was detected.

An alternative approach that allows very accurate measurement of the spatial distribution of radioactive elements in the vicinity of stellar objects is provided by microwave spectroscopy of radioactive molecules such as ^{26}AlF. Radio-telescope facilities, like *ALMA* (Atacama Large Millimeter Array), can identify these species via their characteristic rotational spectra. The astrophysical detection of radioactive molecules requires highly accurate rotational transition frequencies, which can only be obtained from laboratory precision measurements.

While accurate spectra of diatomic molecules can be derived from laboratory measurements of their stable isotopologues, this indirect method fails for triatomic species such as ^{26}AlOH and for all larger species and requires in situ spectroscopic measurements on radioactive molecules. Facilities such as ISOLDE/CERN and TRIUMF in Canada are excellent for producing radioactive molecules in supersonic beams. Spectroscopic studies of radioactive species will enable future astronomical observations that will provide more detailed information about the processes in the interiors of massive stars. In this talk, astrophysically relevant molecules for studies using microwave spectroscopy will be discussed.

[1] C. Tur, A. Heger, S. M. Austin, *Astrophys. J.* **718**, 357 (2010).
[2] R. Diehl *et al.*, *Nature* **439**, 45 (2006).
[3] B. W. Grefenstette *et al.*, *Nature* **506**, 339 (2014).
[4] S. E. Boggs *et al.*, *Science* **348**, 670 (2015).