Unraveling the Sun's chemical past

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Abstract

Central questions in Astronomy are 1) what happened during the first phases of the Solar System formation and 2) how they might have influenced the early development of organic chemistry and perhaps the appearance of life on Earth. The Sun's birth environment being long dissipated, we cannot see what happened in its youth. We can however study solar-mass protostars that are currently forming in other regions of our Galaxy, in order to understand the full story of our own planetary system formation. In this context, several chemical surveys targeting solar-mass protostars have been performed (e.g. Jorgensen et al. 2005, Sakai et al. 2008, Graninger et al .2016, Ceccarelli et al. 2017, De Simone et al. 2017, Higuchi et al .2018, Wu et al. 2019, Belloche et al. 2020, Le Gal et al. 2020, Bouvier et al. 2020, Yang et al. 2021) and showed that not all solar-mass protostars share the same chemical composition. Majority of those studies are however targeting low-mass star-forming regions, in particular because they are closer and thus easier to observe. Yet, our Sun is rather born in a large cluster, with high-mass (M > 8 Msol) stars in its vicinity (e.g. Adams 2010, Pfalzner et al. 2015, Pfalzner & Vincke 2020). Therefore, if we aim to gain more insight into the formation of our own planetary system, we need to target solar-mass protostars belonging to massive star-forming regions.

In this context, we performed a first chemical survey in the Orion Molecular Clouds 2 and 3 (OMC-2/3), the best and closest analogue to the Sun's birth environment, targeting more than a dozen solar-mass protostar. We found that the chemical composition of the OMC-2/3 solar-mass protostars seem to be very different from that of solar-mass protostars located in low-mass star forming regions (Bouvier et al. 2021 in prep). Nonetheless, the statistics are still too poor to draw a final conclusions and we need to perform similar studies in other massive star-forming regions. We thus aim to carry out full unbiased chemical surveys of solar-mass protostars located in low- to high-mass star forming regions to unravel our Sun's chemical past. We thus need (1) a high enough spatial angular resolution to disentangle the protostellar cores because massive star forming regions are further away than low-mass star forming regions, and (2) a large instantaneous bandwidth with dual band observations in order to do multi-frequency surveys to probe the various species usually present in protostellar envelopes. This will be easily achieved with NOEMA thanks the upcoming spectral scan and baseline extension. A step further for NOEMA would be to develop low frequencies to be able to target species for which transitions mainly occur towards those frequencies, such as long carbon chains (frequencies around 40-50 GHz).

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