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Generation of pure H2O-ortho molecular beam with a Stern-Gerlach like experiment for nuclear spin conversion studies

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Water nuclear spin isomers properties are of great interest for astrophysicists regarding information they can potentially provide from celestial ice bodies and interstellar cloud formation [1,2]. Population ratio between magnetic (H2O-ortho; Ms=1) and non-magnetic isomer (H2O-para; Ms=0) at equilibrium is a thermodynamic constant related to the nuclear spin temperature (Tspin). The very weak coupling occurring between H2O magnetic state and its others degrees of freedom like vibration and rotation states results in a lag time for Tspin to reach molecular thermal equilibrium. This lag time is seen as a memory effect potentially holding for millions of years according to some theoretical estimates. Understanding nuclear spin isomers interconversion mechanisms involving intramolecular phenomenon as well as interactions with their environment is crucial to adequately interpret anomalous spin temperature observations in some cometary comae (Tspin= 30 K) and in some star and planet forming regions (Tspin= 10 K). This talk will describe a methodology, developed by our team, that allows to separate H2O-ortho from H2O-para by their focalization in a molecular beam using a magnetic hexapole lens [3,4]. The molecular beam source is shown to be highly enriched in the H2O-ortho using rotationnaly-resolved REMPI-TOF mass-spectrometry techniques which opens the way to perform nuclear spin isomer conversion studies namely state-to-state ortho-H2O scattering on ice surfaces, heterogeneous chemical reactions involving proton exchange and resonant photo-desorption from ortho-ice.

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3. Turgeon et al, Preparation, isolation, storage and spectroscopic characterization of water vapour enriched in the ortho-H2O nuclear spin isomer, Phys.Rev.A 86, 062710 (2012).
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Significance statement

First magnetically enriched ortho-water molecular beam caracterisation in gas phase

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