Producing a Pure Radical Beam Using a Magnetic Guide

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Understanding reactions between ions and radicals at low temperatures is key to building models that accurately describe the chemistry occurring in the atmosphere and the interstellar medium [1]. Complete control of the radical reactant, including velocity and quantum state selection, is important to establish what role each variable plays in the reaction process—but is challenging to achieve in the laboratory. A magnetic guide has been developed to filter selected (target) radicals from a beam containing a mixture of other species. The magnetic guide is made up of four Halbach arrays and two skimming blades, and is positioned after a 12-stage Zeeman decelerator. An evolutionary algorithm has been applied to optimise the passage of H atoms through the decelerator and guide to the detection region, yielding a pure state- and velocity-selected radical beam [2]. The Zeeman decelerator and magnetic guide source will shortly be combined with a cryogenic ion trap, for the study of cold and controlled ion–radical reactions. A second-generation magnetic guide is also being constructed, to act as a stand-alone radical filter. The second-generation guide features additional Halbach arrays and blades, to improve transverse focusing of the beam and to target O and OH radicals. Once constructed and characterised, the second-generation guide will be interfaced with a liquid surface set-up, expanding the scope of radical reactions that can be studied under controlled conditions.

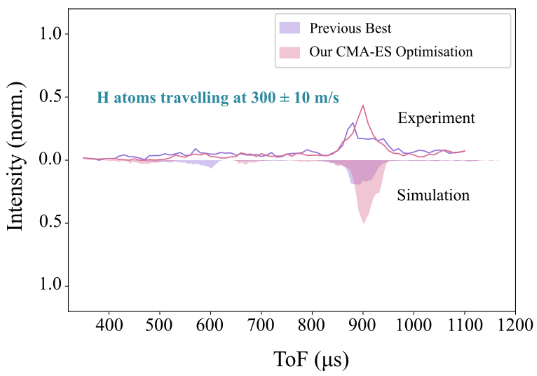

Figure 1: Time-of-flight profiles of the H atom beam, comparing fully optimised parameters to those achieved with our previous best parameters. (Figure adapted from [2].)

[1] Heazlewood, B. R.; Softley, T. P. Towards Chemistry at Absolute Zero. *Nat. Rev. Chem*. **2021**, *5* (2), 125–140.

[2] Mohamed, O.; Wu, L. Y.; Tsikritea, A.; Heazlewood, B. R. Optimizing the Intensity and Purity of a Zeeman-Decelerated Beam. *Rev. Sci. Instrum*. **2021**, *92* (9), 093201.