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Non-destructive detection of molecules without mass limitation

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Our project is aimed at using a laser-cooled trapped ion cloud as a detector for very heavy molecules. The basic principle is to propel a heavy molecular ion with a low charge through an ion cloud while monitoring the fluorescence of the latter. Current techniques have many disadvantages we propose to overcome. While current detection techniques for giant molecules are limited to relatively low mass-to-charge ratios, the high sensitivity of this technique allows detection in cases where the quantity of available sample is very small or when samples are not highly charged.

Numerical simulations using experimentally-accessible parameters predict that it is possible to detect individual, singly-charged molecular ions of unlimited mass using this method. An experimental proof-of-concept set-up is currently under construction. It is based on three elements. Heavy molecular ions are produced with an electrospray source, then guided with electrostatic fields through a $^{40}Ca^{+}$ ion-cloud, i.e our "sensor". This cloud is laser-cooled and trapped in a linear quadrupole Paul trap. Then the fluorescence is monitored and the detection signal is expected to appear in the change in fluorescence intensity due to Doppler effect. Thus the quality of the detection depends on the amplitude and duration of the perturbation of the ion cloud by the giant molecule.

In order to achieve high sensitivity we need to optimize a variety of parameters, including the trapping potential, laser-cooling conditions, and cloud size. The energy of the molecular ion and its trajectory in the cloud must also be well constrained. With both the sensitivity and the operation range of the detector depending on these key parameters, the main goal of our current work is their characterization.

Authors: POINDRON, Adrien (Université d'Aix Marseille); Dr DEDONDER-LARDEUX, Claude; Dr GUY-OMARC'H, Didier; Dr JANULYTE, Aurika; Dr JOUVET, Christophe; Dr PEDREGOSA-GUTIERREZ, Jofre; Dr CHAMPENOIS, Caroline; Dr KNOOP, Martina

Presenter: POINDRON, Adrien (Université d'Aix Marseille)

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