

Time of flight spectrometry of species generated from Matrix Isolation Sublimation

A. N. Oliveira^{1,2}, W. Wolff¹, D. M. Silveira¹, V. L. B. de Jesus³, E. C. Montenegro¹, L. M. Sigaud⁴, *C. L. Cesar¹

¹Instituto de Física, Universidade Federal do Rio de Janeiro, Caixa Postal 68528, 21941-972 Rio de Janeiro, RJ, Brazil

²INMETRO, Av. Nossa Senhora das Graças, 50, Duque de Caxias - RJ, Brazil

³Instituto Federal de Educação, Ciência e Tecnologia do Rio de Janeiro – IFRJ - campus Nilópolis – RJ, Brazil

⁴Instituto de Física, Universidade Federal Fluminense, 24210-346 Niterói, RJ, Brazil

Matrix Isolation Sublimation (MISu) has been used to generate cold and intense beams of atoms and molecules [1]. In this technique, a matrix of Ne or H₂ implanted with atoms of interest – typically via laser ablation – is subsequently sublimated into vacuum generating an atomic beam. One of our goals is the production of heteronuclear molecules in the matrix by successive implantation of its constituents [2]. In order to detect these molecular species formed in the matrix – some of which may be unexpected – time-of-flight spectrometry is better suited than laser spectroscopy which is very specific, and requires both a good knowledge of the transitions frequencies, and a large number of particles for a sensitive signal. We have thus implemented a low energy photoelectron beam to drive such time-of-flight spectrometer.

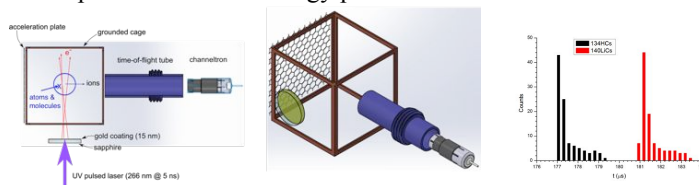


Fig. 1: Schematics of the time-of-flight spectrometer based on low energy photoelectrons. A simulation of this small spectrometer – with ~20 mm acceleration region and 40 mm of free flight – at low voltages (~20 V) is enough to separate ion masses of 134 (HCs) and 140 (LiCs), for example.

The fourth-harmonic of a pulsed Nd:YAG laser at 266 nm is used to generate the photoelectrons from a photocathode material. Initial tests on different surfaces, such as aluminum, copper and gold, with no special treatment, provided electron beams with as much as 10⁸ electrons per pulse, at room temperature. The electron beam can be tuned in energy by applying a negative voltage to the photocathode. While Ne can be ionized at 22 eV, most of the other species will take less than this value to ionize requiring only low voltages for the operation. It is possible to avoid ionization of the major gas constituent, Ne, – if so desired – just by using an electron beam with energy below this threshold. For cryogenic work, we have deposited a gold film onto a sapphire window [7] as a photocathode. In this configuration, the laser path – coming through the window – will not overlap the electron beam and potential grids making the setup easy, as shown in Fig. 1. After the electron beam enters the Faraday cage where the atoms and molecules are ionized, an extraction pulse is applied to the accelerating plate. The ions are pushed towards the field free time-of-flight tube and detected by a channeltron. The time-of-flight spectrometer approximately obeys the Wiley-McLaren condition [9] so as to increase the mass resolution. In our case, the MISu atomic beam has around 1 cm of diameter and therefore we do not focus the electron beam, which has approximately this same diameter.

Despite the selected small dimensions, the time-of-flight (TOF) spectrometer should be able to discriminate the masses of our initial interest species, from atomic isotopes, to molecules such as ^{6,7}Li₂, LiCa, CaH, CaH₂, LiCs and other. In Fig. 2 a SIMION simulation of the TOF with 20 mm of acceleration region – from the center of the sample – followed by a 40 mm free TOF region, molecules with large masses such as CsH⁺ and LiCs⁺ would be discriminated. Molecules with lower masses are more easily distinguishable. In this report we will present initial results as well as various prospects of the technique.

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