Slow ground state molecules from matrix isolation sublimation

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Slow ground state molecules from matrix isolation sublimation

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Synopsis We describe a cryogenic beam of \(^7\)Li\(_2\) dimers from sublimation of a neon matrix where Li atoms have been implanted via laser ablation of solid precursors of LiH. Laser absorption spectroscopy measured: T~7 K, Trot ~ 6K, drift velocity of 130 m s\(^{-1}\) with molecular density of 10\(^9\) cm\(^{-3}\). The formation of molecules in a matrix offers new possibilities.

The production of cold samples or beams of molecules is an ongoing research field with many applications [1], from quantum information to basic physics tests, such as the search for a permanent electric dipole moment of the electron with parity and time reversal symmetries violations. Some molecular species are complex to make in an environment compatible with low temperatures [2], requiring the use of hot ovens.

We describe the generation and properties of a cryogenic beam of \(^7\)Li\(_2\) dimers from sublimation of a neon matrix where lithium atoms have been implanted via laser ablation of solid precursors of metallic lithium or lithium hydride (LiH). The sublimation regime can be controlled to lead to different parameters, such as temperature and forward velocities.

With laser absorption spectroscopy these parameters were measured using the molecular \(^7\)Li\(_2\) \((R)\) transitions \(A^1\Sigma^+_u (v' = 4, J' = J'' + 1) \leftarrow X^1\Sigma^+_g (v'' = 0, J'' = 0, 1, 3)\). In a typical regime, sublimating a matrix at 16 K, translational temperatures of 6–8 K with a drift velocity of 130 m s\(^{-1}\) in a free expanding pulsed beam with molecular density of 10\(^9\) cm\(^{-3}\), averaged along the laser axis, were observed. Rotational temperatures around 5–7 K were obtained. By monitoring the atomic Li signal – in the D2 line – concomitantly with the molecular signal, we see saturation in both the atomic and molecular signal [3].

Based on the data and a simple model, we discuss the possibility that a fraction of these molecules are being formed in the matrix, by mating atoms from different ablation pulses, which would open up the way to formation of other more interesting and exotic molecules to be studied at low temperatures. Such a source of cryogenic molecules have possible applications encompassing fundamental physics experiments, quantum information studies, cold collisions, chemistry, and trapping.

A typical spectrum for the \(A^1\Sigma^+_u (v' = 4, J' = 2) \leftarrow X^1\Sigma^+_g (v'' = 0, J'' = 1)\) transition, at 665.927 nm, are shown in Fig. 1.

![Figure 1](images/figure1.png)

**Figure 1.** (a) Typical spectrum of Li\(_2\) transition at 665.927 nm, black line; (b) best fit to the measured data, red line. The measured parameters \(\Delta \nu_x\) and \(\delta \nu_{DS}\) are related to temperature and forward velocity.

Details of the experimental setup for Matrix Isolation Sublimation (MISu): a neon matrix is grown onto a cryogenic sapphire substrate, and atoms of Li and H are implanted via laser ablation of a solid LiH precursor; atoms and molecules are liberated from the matrix into vacuum with a sublimation heat pulse on the NiCr film resistor on the sapphire, will be presented. Also, details how to generate and characterize the molecular beam will be given.

References

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