Erbium-yttrium symbiosis for quantum information processing

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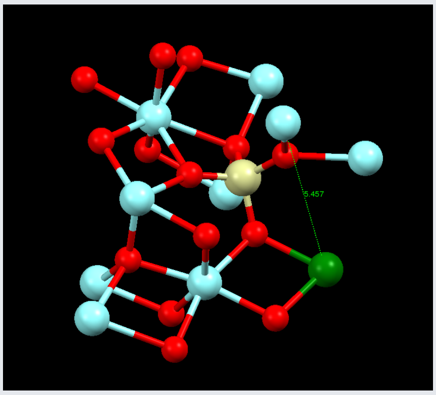
In laser-induced electron diffraction (LIED), low-energy direct and rescattered electron waves may interfere while the high-energy spectrum comes only from rescattering. We take benefit from this property to isolate the electrons from charge resonance enhanced ionization (CREI). In the 1990s, CREI was identified to lead to a noticeable increase of the molecular charge state prior to Coulomb explosion with a moderate increase of the laser intensity [Figures (a) & (b): Ion spectra & covariance maps at 10^{14} & $3{\times}10^{14}$ $\mathrm{Wcm^{-2}}$]. The associated electron emission remains difficult to deal with because CREI is part of an overall multielectron ionization, where the initial step of single ionization of neutral species dominates the electron spectrum [Figure (c): Electron energy < 50 eV].

Spin qubits are a good support for quantum information, because they have a long lifetime, which is an essential feature for the development of applications. Their optical addressability is a major issue, in order to fill the gap between the current optical telecom networks where navigate the photonic carriers and static nodes where the information can be stored and processed. Unfortunately, few spins have both, a long lifetime and an optical addressability.

The LAC team has just proposed a hybrid approach by coupling an optically active ion of erbium, and a long-lived nuclear spin of yttrium. These two compounds are naturally present when erbium is inserted into an yttrium orthosilicate matrix. Er and Y are neighbors and form a symbiotic couple. The presence of multiple yttrium's neighbors around the Er is actually a vast mikado that makes the control particularly delicate and not sufficiently selective to be efficient. The researchers have shown that it is possible to selectively control an Er-Y pair without affecting other neighbors. Their experimental demonstration is based on a good understanding of the exceptional anisotropy of the magnetic field that erbium induces in its vicinity. This anisotropy is at the heart of the selective control of a specific Er-Y pair which then forms a promising pair for the quantum processing of information.



Reduced crystalline cell of yttrium orthosilicate with erbium dopant in green. Yttrium ions are in blue , oxygen in red and silicon in yellow form the Y2SiO5 matrix. Despite the large number of yttrium close to erbium, we have shown that a specific Er-Y pair can be optically addressed (here separated by 5.4A represented by a dashed green line)

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