Self-optically-nanostructuring Raman gases

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We report on novel way of accelerating and trapping molecular hydrogen in a self-organized extremely deep potential nanometre scaled well array [1]. In this new Lamb-Dicke regime of stimulated-Raman-scattering, hydrogen molecules inside a photonic bandgap hollow core fibre are deeply-trapped in self-nanostructured optical lattice to emit watt-level CW Stokes-radiation with sub-Doppler resolved spectral sidebands and with a sub-recoil linewidth as low as ~3 kHz [2], which is ~6 orders-of-magnitude narrower than what conventional stimulated Raman scattering predicts, and nearly 30 times narrower than the hydrogen molecule recoil frequency \( \nu_{\text{recoil}} = \frac{\pi \hbar}{(m_3 \lambda \delta^2)} \) of ~78 kHz (see figure 1).

The Stokes sub-Doppler spectrum shows a rich structure that includes Mollow triplet, molecular motional-sidebands and four-wave-mixing between these sub-Doppler spectral lines.

In addition to this rich spectral structure, we observe a macroscopic dynamics whereby molecule acceleration can be observed with the naked eye via an IR viewer. This motion stems from the fact that the formed lattice of Stokes and trapped molecules exhibits a moving lattice like Wannier-Stark potential with a "tilted" parabolic potential.

This new route of trapping molecules could open new paths in several fields. To mention a few, we count trapping and cooling molecules, with the potential of achieving the same level of accomplishments as those with atoms, or manufacturing of gas nanostructures such as micro-mirrors and micro-cavities as we do with solid-state materials.
