Electric field measurements by coherent anti-Stokes Raman scattering in visible region

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Plasmas generated under high-pressure conditions are widely utilized in various applications, such as plasma agriculture and plasma medicine. Since the acceleration of electrons and/or ions by electric fields serves as a primary energy source in many plasma processes, the electric field is a critical parameter for understanding and controlling plasma behavior.

Here, I present our recent results on non-intrusive electric field diagnostics using electric-field-induced coherent anti-Stokes Raman scattering in the visible region (E-CARSv) in Raman-active media such as hydrogen, nitrogen (air), and water vapor [1–4].

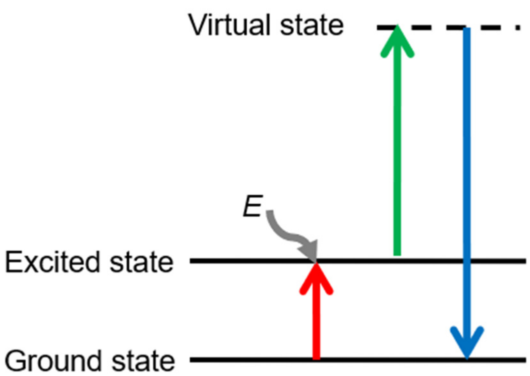

Figure 1. Schematic of the optical energy transition for E-CARSv

In E-CARSv measurements, infrared light (red arrow in Fig. 1), whose energy matches the Raman transition energy, and visible light, e.g. 532 nm (green arrow), are irradiated. When an electric field is present, anti-Stokes light (blue) is generated, with its intensity corresponding to the electric field strength. Phase matching is generally achieved under collinear alignment conditions. Since the signal intensity is proportional to the square of the molecular density, E-CARSv is particularly sensitive in high-density environments, such as those at atmospheric pressure.

Our group has demonstrated E-CARSv generation using hydrogen [1,3], nitrogen [2], and water vapor [4]. Sensitive detection of electric fields has been achieved, such as 0.5 V/mm in an atmospheric-pressure hydrogen environment [1]. By scanning the infrared wavelength, rotational temperatures can also be measured [1]. These rotational temperatures can be used for sensitivity correction when E-CARSv is applied in the environments with elevated temperatures, such as discharges. Such demonstrations will also be presented using hydrogen discharges [3].

Unlike hydrogen or nitrogen, water vapor introduces additional considerations due to the absorption of one of the incident laser beams. However, this absorption also provides valuable insights into the associated molecular density [4]. Therefore, E-CARSv using water vapor may offer advantages over those using hydrogen or nitrogen.

Further details will be presented at the conference.

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