SPECTRAL LINE SHAPE COLLAPSE TO LORENTZ PROFILE UNDER FREQUENT VELOCITY-CHANGING COLLISIONS

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The collapse of spectral line shapes involving speed dependence of collisional width and shift to Lorentz profile under frequent velocity-changing collisions was recognized[1,2] in the past. Phenomenological expression for Lorentzian width of the collapsed profile in the case of velocity-changing collisions described by hard collision model[3] and speed dependence of collisional shift given by quadratic function[4] was proposed, verified numerically, and applied for interpretation of experimental data[5,6]. This finding was supported then by analytical derivation[7]. It was shown that while the effective width increases with speed dependence of collisional shift, it is reduced by speed dependence of collisional width. On the other hand, the effective shift is modified by the thermal average of speed dependence of the product of collisional width and shift.

Recently we went beyond hard collision approximation. For a quadratic speed dependence of collisional broadening and shift, and the billiard ball model of velocity-changing collisions, we provide simple analytical expressions for the effective Lorentzian width and shift[8]. We show that the effective Lorentzian width and shift split into components originating from the: well-known Dicke-narrowed Doppler width, speed-averaged collisional broadening and shift, their speed dependencies, and a product term that mixes the contributions of the broadening and shift speed dependencies. We show how the components depend on rates of speed-changing and velocity-changing collisions related to the perturber/absorber mass ratio. Analytical formulas were numerically validated on an example of H_2 transition perturbed by He.

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