Asymmetric Deviation of the Scattering Cross Section around Lyα by Atomic Hydrogen

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We investighate the asymmetry of the scattering cross section of radiation around Ly α by atomic hydrogen, which may be applied to analyses of scattering media with high column neutral hydrogen densities including damped Lyα absorption systems of quasars. The exact scattering cross section is given by the Kramers-Heisenberg formula obtained from the fully quantum mechanical second-order time dependent theory, where, in the case of hydrogen, each matrix element is given in a closed analytical form. The asymmetric deviation of the scattering cross section from the Lorentzian near the line center is computed by expanding the Kramers-Heisenberg formula in terms of Δω/ωLyα, where ωLyα is the angular frequency of the Lyα transition and Δω/ωLyα is the deviation of incident radiation from ωLyα.

To the first order of ωLyα, we obtain σ(ω)=σT(0.5 f (ωLyα/Δω)2(1-1.79 Δω/ωLyα), where f=0.4162 is the oscillator strength for the Lyα transition. With this deviation, the line center of the damped wing profile appears redward of the true Lyα line center. In the case of a damped Lyα system with a H˜I column density 5x1021 cm-2, the apparent line center shift relative to the true center amounts to $\Delta z\sim 10^{-4}$. With higher column density NHI=4x1022cm-2, the apparent line center shift is $\Delta z=10^{-3}$, which is quite measurable from the current instruments.