Van der Waals and Casimir-Polder Interactions of Hydrogen Atoms in Excited States[1] CHANDRA ADHIKARI, VINCENT DEBIERRE, ULRICH JENTSCHURA, Department of Physics, Missouri University of Science and Technology, Rolla, MO, 65409 — We analyze the long-range interactions between two hydrogen atoms. Provided both atoms are in the ground states, the retardation regime is achieved when the interatomic distance, R, is larger than $137a_0$, where a_0 is the Bohr radius. However, for an excited atom interacting with the ground state atom, the presence of virtually low lying energy levels accessible by a dipole transition from an excited reference state makes the situation different. For excited reference states, we match the scattering amplitude and effective perturbation Hamiltonian of the system. For $a_0 \ll R \ll 137a_0$, the nonretarded approximation is valid and the interaction energy takes a R^{-6} functional form. For a higher excited states, we obtain a numerically large van der Waals coefficient, e.g., about 24000 in atomic units for $12S$-$1S$ system. As soon as the interatomic separation satisfies $R \geq 137a_0$, the interaction energy does not have only the R^{-6} term, but surprisingly it also has (i) attractive/repulsive oscillatory terms, in addition to (ii) the familiar Casimir-Polder R^{-7} asymptotic. For sufficiently large R, the oscillatory term whose magnitude falls off as R^{-2} dominates the Wick-rotated term (the latter describes the retarded Casimir-Polder type of interaction).

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