Spectroscopy and formation of He_2^+

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Determination of time (and space) dependence of the proton-to-electron mass ratio m_p/m_e is still an open problem in modern physics. Molecular absorption and emission spectra detected from distant astronomical objects provide crucial tools for successful derivation of constraints on a possible cosmological variation of m_p/m_e. Apparently, the deepest look-back times can be monitored using the primordial molecules consisting of hydrogen, helium, and possibly of lithium. Molecules, whose transitions are very sensitive to small changes in the reduced mass and hence to the m_p/m_e variations, are key stones of such studies. In our study, we focus on one such promising candidate – helium dimer cation He_2^+.

First, the rovibronic spectrum of He_2^+ is analyzed for purposes of detecting a possible cosmological variation of the proton-to-electron mass ratio m_p/m_e [1]. We show that some of its microwave transitions [2] have very large sensitivity coefficients, which rival the latest state-of-the-art results of Ref. [3], where a stringent constraint on the change in the proton-to-electron mass ratio at a redshift of 0.89 has been established.

Secondly, we study the possibility of the He_2^+ formation in distant astronomical objects. We concentrate on the processes of spontaneous and stimulated radiative association of He with He^+. We present the rate coefficients for these processes as function of temperature considering the association to the rotational-vibrational states of the electronic ground state from the continuum states of the excited electronic states [4,5].

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