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Ripplonic Lamb shift for electrons on liquid helium DENIS KONSTANTINOV, Okinawa Institute of Science and Technology, Japan, KONO KIMITOSHI, RIKEN, Japan, MICHAEL LEA, Royal Holloway, University of London, UK, MARK DYKMAN, Michigan State University, USA — We resolve a long-standing controversy regarding the electrons on the surface of helium and their coupling to capillary waves, ripplons. The direct two-ripplon coupling to short-wavelength ripplons is strong. It leads to a strong power-law ultraviolet divergence of the shifts of the electron energy levels and to a high energy relaxation rate of the excited states. We use the Bethe-type approach to show that one-ripplon processes, taken to the higher order of the perturbation theory, compensate the divergence of the level shifts. The resulting shifts, which are ripplonic analogs of the Lamb shift, are small. The transition frequencies display characteristic temperature dependence. The calculation of this dependence with no adjustable parameters for transitions between the two lowest subbands of motion along the surface is in good agreement with our experimental data. We also show that one-ripplon processes renormalize the energy relaxation rate, which for highly excited electron states is determined by two-ripplon emission. As a result, energy relaxation is much slower than the lowest-order theory predicts. This is important for applications of electrons on helium in quantum information.

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