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Critical Binding Conditions for Two-electron Atoms

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There has been a recent revival of interest in the critical nuclear charge Z_c that is just sufficient to bind a nucleus of charge Z and two electrons in the 1sˆ2 ˆ1S ground state [1–3]. It is conjectured that the inverse of critical charge is related to the radius of convergence 1/Z* for a 1/Z expansion of the energy of the form E(Z) = Zˆ2(E_0 + E_1/Z + E_2/Zˆ2 + ...). We have performed high precision variational calculations in Hylleraas coordinates, using the double basis set method [4], for values of Z very close to Z_c, with basis sets containing up to 2809 terms (\Omega = 24). Our current result is Z_c = 0.911 028 224 077 255 73(4), corresponding to 1/Z_c = 1.097 660 833 738 559 80(5). This result agrees with the older result Z_c = 0.911 028 [1], but disagrees with a more recent result Z_c = 0.910 850 [2]. Well-defined eigenvalues continue to appear for Z < Z_c, possibly corresponding to quasibound states in the scattering continuum due to a shape resonance induced by the polarization potential of the core.

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