Infrared renormalization and infraparticle states in QED

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We consider a freely propagating, non-relativistic, charged particle interacting with the quantized, ultraviolet regularized electromagnetic field. Introducing an infrared regularization σ_0, we study $H_p(\sigma_0)$, the restriction of the corresponding hamiltonian to the fiber Hilbert space $\mathcal{H}_p$ associated to the conserved total momentum p. For $|p|$ sufficiently small, we show that $E_0(|p|, \sigma_0) = \text{infspec}(H_p(\sigma_0))$ is an eigenvalue, and that $E_0(|p|, \sigma_0) - \frac{|p|^2}{2}$ has small first and second derivatives w.r.t. $|p|$, uniformly in σ_0. Furthermore, the corresponding eigenvector is an element of $H_p(\sigma_0)$ for all $\sigma_0 > 0$, but not in the limit $\sigma_0 \to 0$. The proof is based on the Bach-Fröhlich-Sigal operator-theoretic renormalization group.