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Effective Field Theory for Rydberg Polaritons M. J. GULLANS, Y. WANG, Joint Quantum Institute, J. D. THOMPSON, Harvard University, Q.-Y. LIANG, V. VULETIC, Massachusetts Institute of Technology, M. D. LUKIN, Harvard University, A. V. GORSHKOV, Joint Quantum Institute — Photons can be made to strongly interact by dressing them with atomic Rydberg states under conditions of electromagnetic induced transparency. Probing Rydberg polaritons in the few-body limit, recent experiments were able to observe non-perturbative two-body effects including: single photon switching and the formation of bound states. Although the two-body problem is amenable to exact solutions, such approaches quickly become intractable for more than two particles. To overcome this problem, we study non-perturbative effects in N-body scattering of Rydberg polaritons using effective field theory (EFT). For attractive interactions, we show how a suitably long medium can be used to prepare shallow N-body bound states in one dimension. We verify this prediction for two and three photons using full numerical simulations. We then consider conditions under which the effective interactions are repulsive and study two and three photon transmission. Finally, we show how to go beyond EFT by measuring the three-body contact force or, alternatively, scattering at high relative momenta.

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