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Effective Field Theory for Strongly Correlated Photonic Matter
MICHAEL GULLANS, JACOB TAYLOR, NIST - Natl Inst of Stds Tech, YIDAN WANG, University of Maryland, College Park, JEFF THOMPSON, Princeton University, QIYU LIANG, VLADAN VULETIC, Massachusetts Institute of Technology, MIKHAIL LUKIN, Harvard University, ALEXEY GORSHKOV, NIST - Natl Inst of Stds Tech — A promising route to scaling up quantum information systems is to strongly couple light, or other propagating quantum fields, to localized electronic degrees of freedom in solids or trapped atoms. Describing the emergent non-equilibriumbehavior of such strongly coupled light and matter is an outstanding challenge for theoretical physics and quantum information science. A simplifying feature of these systems, however, is that they are oftencharacterized by a large separation of scales between the atomic and photonic degrees of freedom. In this talk, I will discuss recent results where we took advantage of this separation of scales to develop an effective field theory description of interacting photons in cold gases of Rydberg atoms, where the photons become dressed with highly excited Rydberg states. This theoretical approach is analogous to semiclassical nonlinear optics,where the electronic degrees of freedom are integrated out to give rise to effective photon-photon interactions. As an application of this theory, I will show how such Rydberg polariton systems may provide new insights into universality in few-body quantum systems.

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