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Towards analog reheating of the universe in the laboratory

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The early universe has undergone a transition from a super-cooled state after cosmic inflation to a hot and thermal one. We propose an analog experimental implementation of this cosmic reheating dynamics using an ultra-cold Bose gas. In our mapping, a Bose-Einstein condensate plays the role of the inflaton field, which describes the state of the universe after inflation. The expansion of the universe as well as the dynamics of the inflaton field are encoded in the time-dependence of the atomic interaction, which can be tuned via Feshbach resonances. By means of classical-statistical simulations we illustrate that the dynamics of the system involves the known stages of reheating. At early times, parametric instabilities lead to the production of Bogoliubov quasi-particles as excitations on top of the condensate, mimicking cosmological particle production by the decaying inflaton field. At later times, the system develops a turbulent cascade transporting energy to higher momenta in a self-similar way. The final stage of the dynamics, where the system relaxes to thermal equilibrium, is dominated by quantum fluctuations and therefore not captured by the classical-statistical approximation, which motivates an experimental study of this process using a quantum simulator."

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