Route to chaos in an atom-cavity system

H. Keßler[*1],
P. Kongkhambut [1], **J. Skulte** [1], **L. Mathey** [1,2], **J. G. Cosme** [3],
A. Hemmerich [1,2]

1. Zentrum für Optische Quantentechnologien and Institut für Laser-Physik, Universität Hamburg, 22761 Hamburg, Germany

2. The Hamburg Center for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, German

3. National Institute of Physics, University of the Philippines, Diliman, Quezon City 1101, Philippines

In driven non-linear systems various kinds bifurcations can be observed on their route to chaos. From the evolution of Floquet multipliers one can extract information which serves as precursors of phase transitions and dynamical instabilities. This method is applied in classical non-linear physics for example as early warning signals. Using our very well controlled atom-cavity platform, we are able to prepare our system in these different regimes and study the bifurcation theory experimentally in a quantum gas. Therefore, we pump our setup perpendicular to the cavity axis with a standing wave light field. Crossing a critical pump strength, we observe a pitchfork phase transition from a normal to a steady state self-organized phase [1]. Employing an open three level Dicke model, this transition can be understood as by a transition between two fix points. If the pump strength is increased further, the system over-goes a Hopf-bifurcation and limit cycles, which have time crystalline properties, emerge [2]. In our model we cannot find fix points in that parameter regime but stable attractive orbits. For strong pumping, we observe a second bifurcations, in our case a Neimark-Sacker bifurcation. The main characteristics is an oscillation with two incommensurate frequencies, which can me dubbed a continuous time quasicrystal [3]. Finally, we observe chaotic dynamics with many contributing frequencies.

References

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[*]hkessler@physnet.uni-hamburg.de