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Topographic fibers: a platform for fundamental physical phenomena

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Summary

We review the fundamental physical phenomena associated with parametric resonance which can be successfully investigated in topographic fibers characterized by suitably engineered oscillating dispersion.

Introduction and Results

Engineering the dispersive properties of waveguides is an important issue in nanophotonics. On a different length scale this can be achieved in optical fibers by suitably controlling their longitudinal properties, leading to so-called topographic fibers. In this framework, fibers with oscillating dispersion have generated a lot of interest recently [1]. Peculiar properties of parametric photon conversion processes arise in these fibers via parametric resonance phenomena induced by the periodicity of the dispersion. Here we review the recent theoretical results as well as the observation made through experiments performed at University of Lille in this area.

First, at variance with standard fibers, modulational instability (MI) can be observed in these fibers in the normal dispersion regime, thanks to the quasi-momentum contribution due to the periodicity. Parametric resonance conditions predict accurately the multiple unstable bands observed in experiments. Theoretical efforts have permitted to characterize also the fully depleted stage of MI [2]. Quasi-recurrences of the Fermi-Pasta-Ulam type are predicted despite the non-integrability of the underlying model. Moreover, the optimal conditions for conversion substantially deviate from those predicted by parametric resonance, due to a complicated phase-space structure of the instability.

An other interesting case is that of a passive externally driven resonator built with an intracavity fiber with oscillating dispersion. In this case the stationary response of the cavity is bistable, and two different kind of instabilities can compete. On the lower branch of the response MI is of the Turing type, which exists also in the limit of homogeneous (normal) dispersion. Conversely, at higher power, switching to the upper branch is accompanied by the onset of a different instability, namely of the Faraday type, which exists only due to the periodicity and can be interpreted again in terms of parametric resonance. The theory agrees well with the observation of this phenomenon [3]. Moreover we have reported in this structure the first observation of the onset of period-2 dynamics resolved over successive individual round-trips.

References

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