CRC 1227
Designed Quantum States of Matter

GUEST LECTURE

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Physikalisch Technische
Bundesanstalt Bundesallee 100,
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"Spontaneous creation, dynamics and interaction of vortices in Bose-Einstein condensates"

When a system crosses a second-order phase transition on a finite timescale spontaneous symmetry breaking can cause the development of domains with independent order parameters, which then grow and approach each other creating boundary defects. This is known as Kibble-Zurek mechanism [1,2]. Originally introduced in cosmology, it applies both to classical and quantum phase transitions, in a wide variety of physical systems. We will discuss the conditions for the spontaneous creation of defects in Bose-Einstein condensates via the Kibble-Zurek mechanism and we will show that its typical signatures, such as the power-law scaling of the defects density on the quench time, can be recovered [3]. These defects are identified as quantum vortices orthogonally oriented to the symmetry axis of the confining trap, as expected for solitonic vortices in a highly anisotropic condensate [4].
The real-time dynamics of vortices can be followed in the condensate using a weakly destructive stroboscopic technique, hence allowing for an accurate comparison between experimental data and theoretical models of dynamics of vortices in superfluids [5]. In configurations with two vortex lines simultaneously present in the condensate signatures of interaction are observed in the form reconnections, rebounds and annihilation [6]. This opens a new perspective to studies in the domain of quantum turbulence.

[1] T. Kibble, Physics Reports 67, 183 (1980).
[2] W. H. Zurek, Nature 317, 505 (1985).
[3] G. Lamporesi et al., Nature Phys. 9, 565 (2013).
[4] S. Donadello et al., Phys. Rev. Lett. 113, 065302 (2014).
[5] S. Serafini et al., Phys. Rev. Lett. 115, 170402 (2015).
[6] S. Serafini et al., PRX 7, 021031 (2017).

All DQ-mat members and all interested are cordially invited to attend.