Tata Institute of Fundamental Research
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Seminar

When waves meet vortices: A topological twist in water

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Wave-topology interactions lie at the heart of numerous physical phenomena from condensed matter systems to cosmological models; the well-known Aharonov-Bohm (AB) effect in Quantum Mechanics is but a striking example. This effect has classical analogues, notably in fluid dynamics where surface waves scatter off of vortices, creating wavefront dislocations, as shown in a now famous bath tub experiment by Sir Michael Berry and colleagues in 1980. Previous works have focused on traveling waves, with the number of wavefront dislocations determined by a parameter that relates vortex circulation to wave properties. In such classical analogues, the influence of vortex topology is manifested in local, short-range effects. However, neither the full potential of stationary waves revealing topological features, nor the non-local character that topology introduces in the AB effect have been explored or exploited to the best of our knowledge.

In this talk, I'll present a theoretical, numerical, and experimental study of standing waves scattered by a stationary vortex which induces global (non-local) nodal structures -- lines of zero wave amplitude -- the number of which is quantised, and may exhibit temporal oscillations. This is in striking contrast with earlier observations, where interactions were confined or lacking such topological regularity. Since phase is measurable in classical settings but not a physical observable in the quantum realm, these findings could potentially pave the way for hydrodynamic emulation of quantum interference phenomena. Potential instances include AB caging and topological localisation providing a simple, yet powerful, platform for exploring wave-topology interplay with potential implications for photonic, acoustic, and quantum metamaterials.

Friday, Jul 11th 2025

16:00 Hrs (Tea / Coffee 15:45 Hrs)

Auditorium, TIFRH