Long-time simulation of spherical hydrodynamics via quantization

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Incompressible inviscid hydrodynamics on the sphere constitute a basic model in geophysical fluid dynamics. To understand the qualitative long-time behavior in such models is a fundamental problem in mathematical physics. The equations of motion possess a Poisson structure that gives rise to infinitely many conservation laws (Casimir functions) in addition to conservation of energy and momentum. To preserve this structure in discretizations is notoriously difficult, yet essential to capture the correct long-time behavior; the only known approach, due to Zeitlin (1991), is based on quantization theory. In this talk I show how Zeitlin's approach, developed for the flat 2-torus, can be adopted to the sphere. Indeed, for differential geometric reasons it works even *better* on the sphere than on the torus! Furthermore, the quantized equations themselves give new insights, such as a natural separation of variables that captures scale separation previously seen in both numerical simulations and direct observations of the atmosphere.