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From Navier-Stokes to Einstein

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We discuss a mathematically precise realization of suggestions of a holographic duality relating fluids and spacetime horizons which began with the black hole membrane paradigm in the 70's and resurfaced recently in studies of the AdS/CFT correspondence. Our explicit construction shows that every solution of the incompressible Navier-Stokes equation can be related to a solution of the vacuum Einstein equations. The fluid described by the Navier-Stokes equation in $p+1$ dimensions lives on the timelike boundary of the $p+2$ dimensional Einstein solution. We consider a "near-horizon" limit in which the boundary surface becomes highly accelerated. The near-horizon expansion in gravity is shown to be mathematically equivalent to the hydrodynamic expansion in fluid dynamics, and the Einstein equation reduces to the incompressible Navier-Stokes equation. Moreover, we discuss a connection to the Petrov classification of spacetimes in four dimensions (and its higher dimensional generalizations).

Summary

We discuss a holographic connection between the Navier-Stokes equation and the Einstein equations.

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