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The origin of the self-organization of the 2D Euler fluid flows[1]
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— The 2D ideal incompressible fluid is usually described in terms of streamfunction, velocity and vorticity. An equivalent model consists of a discrete set of point-like vortices interacting in plane by a long-range potential. The essential property of the latter model is that it re-formulates the description in terms of matter, field and interaction. We first extend the model to reflect the parity-invariance and show that returning to continuum it leads to a field-theoretical formulation, with a Lagrangian density for a nonlinear scalar (matter) field, a gauge field and their minimal interaction. A fundamental property of the 2D Euler fluid is revealed in this way: the extremum of the action functional shows Self-Duality, a property known to generate coherent structures (almost all known solitons and instantons in the natural systems). We derive analytically the sinh-Poisson equation, governing the stationary states at relaxation.The presence of the Chern- Simons part in the Lagrangian explains why in 3D the fluid will never relax to a stationary coherent flow. Connections with 4D fermion systems (Nambu-Jona-Lasinio) and with surfaces of constant mean curvature (CMC) will be presented. Stability of certain regular flows results from the property of non-self- intersection of CMC surfaces embedded in 3D space.

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