1049-35-157 **Jalal Shatah** and **Chongchun Zeng*** (zengch@math.gatech.edu). *Free boundary problems of the Euler equation: local well-posedness and hydrodynamical instabilities.*

We consider the evolution of fluid-vacuum surfaces and fluid-fluid interfaces, which may involve vorticity, gravity, or surface tension. The evolution of these free fluid surfaces and the velocity fields is determined by the free boundary problem of the Euler's equation. These problems can be considered in a Lagrangian formulation on infinite dimensional Riemannian manifolds of volume preserving diffeomorphisms. In this setting, the physical pressure turns out to come from the combination of the gravity, surface tension, and the Lagrangian multiplier. The vorticity is naturally related to an invariant group action. In the absence of surface tension, the well-known Rayleigh-Taylor and Kelvin-Helmholtz instabilities appear naturally related to the signs of the curvatures of those infinite dimensional manifolds. The surface tension produces a stronger conservative force than the instabilities and thus regularizes the surface evolution. Based on these considerations, we obtain the local well-posedness of these problems with surface tension in a rather uniform energy method. In particular, for the cases without surface tension which do not involve hydrodynamical instabilities, we obtain the local existence of solutions by taking the vanishing surface tension limit. (Received March 02, 2009)