Hurricane in the Cup: Vortices' Trochoidal Motion and the Effects of Instability During Diffusion in Liquids

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Fluid dynamics is a complex topic involving many phenomena that can be observed in everyday life. The research presents the phenomenon of milk diffusion in coffee and other substances, considered from the perspective of the dynamic of vortices forming during the process. The hypothesis that there are similar properties of vortices in chosen liquids and a larger-scale ones was tested. A camera and a thermal imaging camera were used to record the phenomenon, which enabled a more precise analysis. The necessary parameters were controlled by the created model, which consisted of a cup placed on a rotating disc with adjustable rotational speeds and a syringe on a stand located above the vessel. The measurements showed the dependence of vortices' properties (e.g. velocity of forming, number of vortices, motion features) on the factors, such as the temperature of the fluids, the volume ratio or the direction and speed of rotation of the disc on which the cup is placed. The analysis, based on recordings, showed that trochoidal motion rules apply and there were structures that indicate Rayleigh- Taylor and Kelvin- Helmholtz instabilities. On the basis of the identified instability effects, simulation, that shows the approximate course of the phenomenon, was created. The analysis also showed similarities to larger-scale phenomena, such as the mechanism of hurricane formation.

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