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Motion of fluid particles and stretching of line elements of an ideal fluid

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Two-dimensional motion of fluid particles in an ideal fluid is studied in the framework of the differential geometry of a group of diffeomorphisms. First, the influence of small perturbations to the initial velocity field is investigated on the average distance of fluid particles between the original and the perturbed velocity fields. It is found that departure of the average distance from a linear time evolution is determined by the sectional curvature. Some illustrative examples are presented to show influence of the sign of the curvature. Next, stretching of line elements in turbulent flows is investigated, where the curvature is found to be negative on the average in this problem. This gives evidence of the exponential growth of stretching, which is obtained by an approach from a new direction. Numerical calculations have been carried out for comparison with these results. The ratio of the numerically obtained stretching exponent to the theoretical one is found to be around 1.5.