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Symmetry detectives offer an automated method to classify the symmetries of solutions to dynamical systems – we shall illustrate on a coupled-droplet oscillator problem. This is achieved by mapping a trajectory into an appropriate representation space and detecting symmetry by computing distances to fixed point subspaces of subgroups. The primary application of detectives has been the determination of symmetries of attractors as well as the detection of symmetry-changing bifurcations. In contrast, we utilize symmetry detectives in our analysis of the trajectories of a fourth-order S_3 symmetric model of three coupled inviscid liquid droplets. Since there is no dissipation in the model, there are no asymptotically stable attractors. Hence, solutions away from equilibrium are the focus. In particular, we examine trajectories with no initial velocity. Results of the symmetry detective approach are contrasted to a computation of the largest Lyapunov exponent, which indicates whether dynamics are chaotic or quasiperiodic. Both methods can be applied to a grid of initial conditions in an automated fashion. Our results demonstrate a strong correlation between symmetries and nonlinear dynamics. (Received September 22, 2010)