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Partially Integrable Dynamics of Populations of Nonidentical Oscillators with Global Nonlinear Coupling

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We consider ensembles of sine-coupled phase oscillators consisting of subpopulations of identical units, with a general heterogeneous coupling between subpopulations. Using the Watanabe-Strogatz ansatz we reduce the dynamics of the ensemble to a relatively small number of dynamical variables plus microscopic constants of motion. This reduction is independent of the sizes of subpopulations and remains valid in the thermodynamic limits, where these sizes or/and the number of subpopulations are infinite. We demonstrate that the approach to the dynamics of such systems, recently proposed by Ott and Antonsen, corresponds to a particular choice of microscopic constants of motion. The theory is applied to the standard Kuramoto model and to the description of two interacting subpopulations, exhibiting a chimera state. Furthermore, we analyze the dynamics of the extension of the Kuramoto model for the case of nonlinear coupling and demonstrate the multistability of synchronous states.