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Esen, Oğul; **Han, Daozhi**; **Şengül, Taylan**; **Wang, Quan**

On the nonlinear stability and the existence of selective decay states of 3D quasi-geostrophic potential vorticity equation. (English) Zbl 1479.76041

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Summary: In this article, we study the dynamics of large-scale motion in atmosphere and ocean governed by the 3D quasi-geostrophic potential vorticity (QGPV) equation with a constant stratification. It is shown that for a Kolmogorov forcing on the first energy shell, there exist a family of exact solutions that are dissipative Rossby waves. The nonlinear stability of these exact solutions are analyzed based on the assumptions on the growth rate of the forcing. In the absence of forcing, we show the existence of selective decay states for the 3D QGPV equation. The selective decay states are the 3D Rossby waves traveling horizontally at a constant speed. All these results can be regarded as the expansion of that of the 2D QGPV system and in the case of 3D QGPV system with isotropic viscosity. Finally, we present a geometric foundation for the model as a general equation for nonequilibrium reversible-irreversible coupling.

MSC:

76E20 Stability and instability of geophysical and astrophysical flows
76E30 Nonlinear effects in hydrodynamic stability
76U65 Rossby waves
86A10 Meteorology and atmospheric physics

Keywords:

Kolmogorov forcing; first energy shell; dissipative Rossby wave; nonlinear stability; quasi-geostrophic equation; selective decay state

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