AAS21-07 会場:313 時間:4 月 30 日 11:00-11:15

くりこみ群の方法を用いた重力波の自発的放射メカニズムの物理的解釈
Physical interpretation on the mechanisms of spontaneous gravity wave radiation using the renormalization group method

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Gravity waves (GWs) are categorized into orographic ones and non-orographic ones. The mechanisms for non-orographic GW radiation are not clear, because the dynamics is quite nonlinear and complicated unlike orographic GWs. Recently it has been revealed that GWs are spontaneously radiated from an approximately-balanced flow, especially in the jet/front systems (e.g., O ' Sullivan and Dunkerton 1995). The balanced adjustment theory proposed by Plougonven and Zhang (2007) is considered to be the most likely to describe the spontaneous radiation. However, their theory does not give physical interpretations on GW sources and radiation mechanisms. In this study, we derived a new theory and made physical interpretations.

Using the renormalization group (RG) method (Chen et al. 1996), which is a singular perturbation method, the interaction between the vortical flow and the Doppler-shifted GWs which both have slow time-scales is formulated for the hydrostatic Boussinesq equations on the f plane. In general, the RG method enables us to extract slowly-varying components systematically and naturally from the system containing multiple timescale motions. The derived time evolution equations (RG equations, referred to as RGEs) describe the spontaneous radiation of GWs from the components slaved to the vortical flow through a quasi-resonance together with the GW radiation reaction on the large-scale vortical flow. The quasi-resonance occurs when the space and time scales of slaved components are comparable to those of GWs (quasi-resonance condition).

The RGEs are validated using numerical simulations of the vortex dipole by Japan Meteorological Agency Nonhydrostatic Model. The flow near the dipole center is quite strong due to the confluence, which is similar to a localized jet stream in the atmosphere. GW distribution obtained by the RGE integration accords well with the numerical simulation. This result supports the validity of our theory.

The main GW sources in the vortex dipole can be classified into two groups by using the RGEs. The GW sources in the first group are the slaved components produced by the horizontal divergence of acceleration of the vortical flow near the dipole center (Fig. A). The acceleration can be regarded as the sum of Coriolis and pressure gradient forces. This fact indicates that the GW sources express the horizontal compression of fluid. The horizontal compression can produce vertical motion, which radiates GWs when its space and time scales satisfy the quasi-resonance condition. This radiation mechanism corresponds to the velocity-variation mechanism proposed by Viúdez (2007).

The slaved component in the other group is mainly produced by the vortical flow over the deformed potential temperature surfaces (Fig. B). The deformation of potential temperature surfaces can be attributed to the Bernoulli effect due to the strong vortical flow near the dipole center. The vortical flow over the deformed potential surfaces can produce vertical motion, which radiates GWs when its space and time scales satisfy the quasi-resonance condition. In other words, the deformed potential temperature surfaces act like a mountain as in the radiation process of orographic GWs. This radiation mechanism corresponds to the mountain-wave-like mechanism proposed by McIntyre (2009).

キーワード: 重力波, ジェット気流, 自発的放射, くりこみ, 波, 特異摂動法
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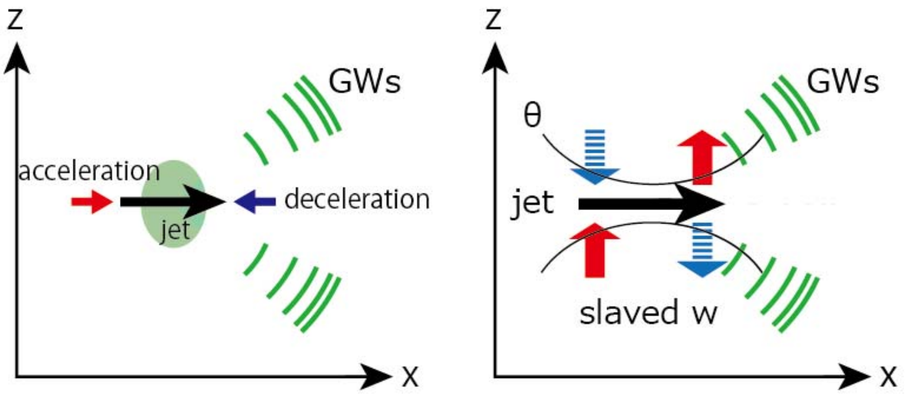

(A) velocity-variation mechanism (B) mountain-wave-like mechanism