磁場の影響のある対流に見られるパターンの遷移

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Transitions of convection patterns in thermal convection under a magnetic field

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Large-scale flow structure in the outer core and its variation may have relation to the geomagnetic field generation and polarity reversals. To study fundamental spatial structures of convective flow and their time variations, we performed both laboratory and numerical simulations of Rayleigh-Benard convection of an electrically conductive low-Prandtl-number fluid under a uniform horizontal magnetic field. The flow pattern is constrained, as the axes of convection rolls tend to align in the direction of the horizontal magnetic field. Transitions of flow structure such as repetition of reversals of flow direction occur when the intensity of the magnetic field is in a limited range for a given Rayleigh number. By analyzing both the laboratory experiments and numerical simulations, we clarified the process of transitions as well as their mechanism. The process can be regarded as an interaction between aligned convection rolls and global-scale mean flow. The occurrence of global circulation bends the aligned rolls in a style of the skewed-varicose instability and induces roll number reduction. In the other point of view, the transitions can be regarded as a competition between two flow modes having different roll numbers. To extract the fundamental flow structures and to quantify the mean roll number existing in time varying flow patterns, we utilize the proper orthogonal decomposition (POD) analysis. We succeeded in identifying competitive modes with time variations of their amplitudes. Convective flow regimes seen in the present setting are clearly classified by a few fundamental flow modes and variations of their relative intensities in time.