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The role of slow magnetostrophic waves in dipole formation in rapidly rotating dynamos

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It is known that the columnar structures in rapidly rotating convection are affected by the magnetic field in ways that enhance their helicity. This may explain the dominance of the axial dipole in rotating dynamos. Dynamo simulations starting from a small seed magnetic field have shown that the growth of the field is accompanied by the excitation of convection in the energy-containing length scales. Here, this process is studied by examining axial wave motions in the growth phase of the dynamo for a wide range of thermal forcing. In the early stages of evolution where the field is weak, fast inertial waves weakly modified by the magnetic field are abundantly present. As the field strength(measured by the ratio of the Alfven wave to the inertial wave frequency) exceeds a threshold value, slow magnetostrophic waves are spontaneously generated. The excitation of the slow waves coincides with the generation of helicity through columnar motion, and is followed by the formation of the axial dipole from a chaotic, multipolar state. In strongly driven convection, the slow wave frequency is attenuated, causing weakening of the axial dipole intensity. Kinematic dynamo simulations at the same parameters, where only fast inertial waves are present, fail to produce the axial dipole field. The dipole field in planetary dynamos may thus be supported by the helicity from slow magnetostrophic waves.