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Large-scale three-dimensional MHD numerical experiment on the solar flux emergence and the formation of active region

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To study the formation of solar active regions, we perform three-dimensional magnetohydrodynamic (MHD) experiment on the flux emergence from a depth of 20,000 km.

It is widely thought that the flux generated at the bottom of the convection zone rises through the interior and appears at the surface to form an active region. Previous studies on flux emergence have been separated into two groups: one is the study on the emergence in the interior and the other on that above the surface. Thus, as a next step, we aim to research the flux emergece from the deep interior to the corona in a consistent manner.

In our preceding studies, we have carried out two-dimensional calculations on the flux emergence from -20,000 km and found the condition of the flux tube as field strength 10^4 G, total flux 10^{21}-10^{22} Mx, and the sufficient twist $> 5.0\text{x}10^{-4}$ km^{-1}. Using these values, we simulate the three-dimensional calculation and find the features as follows. (1) The emerging flux becomes flat beneath the surface. (2) Secondary evolutions to the corona occurs due to the interchange-mode instability. (3) The evolution is consistent with the AR observation by Strous and Zwaan (1999). On the basis of the results above, we newly suggest the model for the flux emergence and the formation of active region.

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