3D PROMINENCE-HOSTING MAGNETIC CONFIGURATIONS: CREATING A HELICAL MAGNETIC FLUX ROPE

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Abstract

The magnetic configuration hosting prominences and their surrounding coronal structure is a key research topic in solar physics. Recent theoretical and observational studies strongly suggest that a helical magnetic flux rope is a key ingredient to fulfill most of the theoretical and observational requirements for hosting prominences. The formation of a flux rope has to date been studied by models based on force-free extrapolations or zero-beta magnetohydrodynamic simulations. The key process, involving magnetic reconnection of sheared magnetic arcades at polarity inversion lines, has not fully been demonstrated. To understand flux rope formation details and obtain magnetic configurations suitable for future prominence formation studies, we here report on three-dimensional isothermal magnetohydrodynamic simulations including finite gas pressure and gravity. Starting from a magnetohydrostatic corona with a linear force-free bipolar magnetic field, we follow its evolution when introducing vortex flows around the main polarities and converging flows towards the polarity inversion near the bottom of the corona. The converging flows bring feet of different loops together above the polarity inversion line and magnetic reconnection happens. Outflow signatures of the reconnection process are identified, and the thereby newly formed helical loops wind around pre-existing ones so that a complete flux rope grows and ascends. When a macroscopic flux rope is formed, we switch off the driving flows and find that the system relaxes to a stable state containing a helical magnetic flux rope embedded in an overlying arcade structure. This is the first numerical demonstration of large-scale stable helical flux rope formation which includes plasma and gravitational stratification effects. This paves the way to true ab-initio simulations for prominence-hosting magnetic configurations.

Keywords: magnetic flux rope, reconnection, prominence, MHD simulations

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