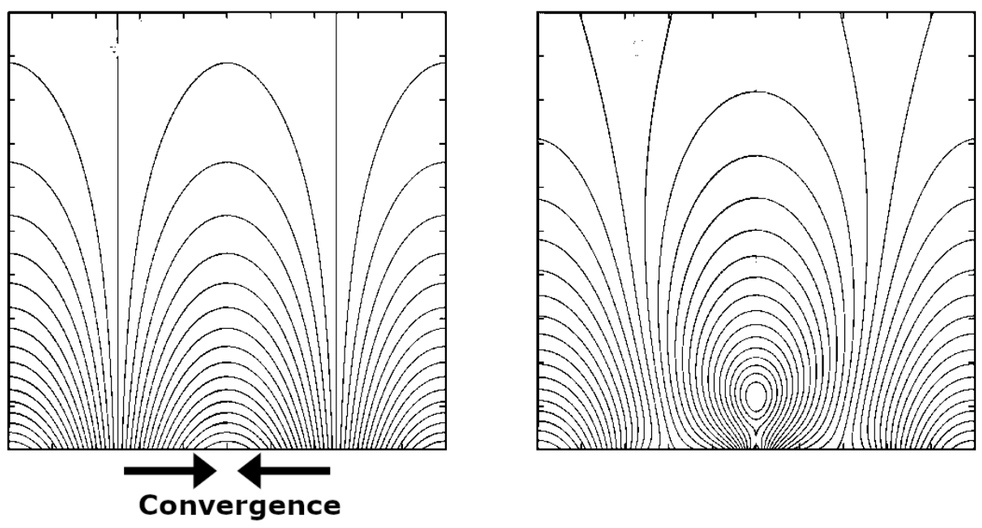
Xiaozhou Zhao, Rony Keppens
Centre for mathematical Plasma Astrophysics, KU Leuven, Belgium.
Acknowledgement: We acknowledge support by a joint FWO-NSFC grant G0E9619N. R.K. received funding from the European Research Council (ERC) under the European Unions Horizon 2020 research and innovation programme (grant agreement No.833251 PROMINENT ERC-ADG 2018), and from Internal Funds KU Leuven, project C14/19/089 TRACESpace.

MHD Simulation of Solar Prominence Formation and Eruption

(A) Levitation model

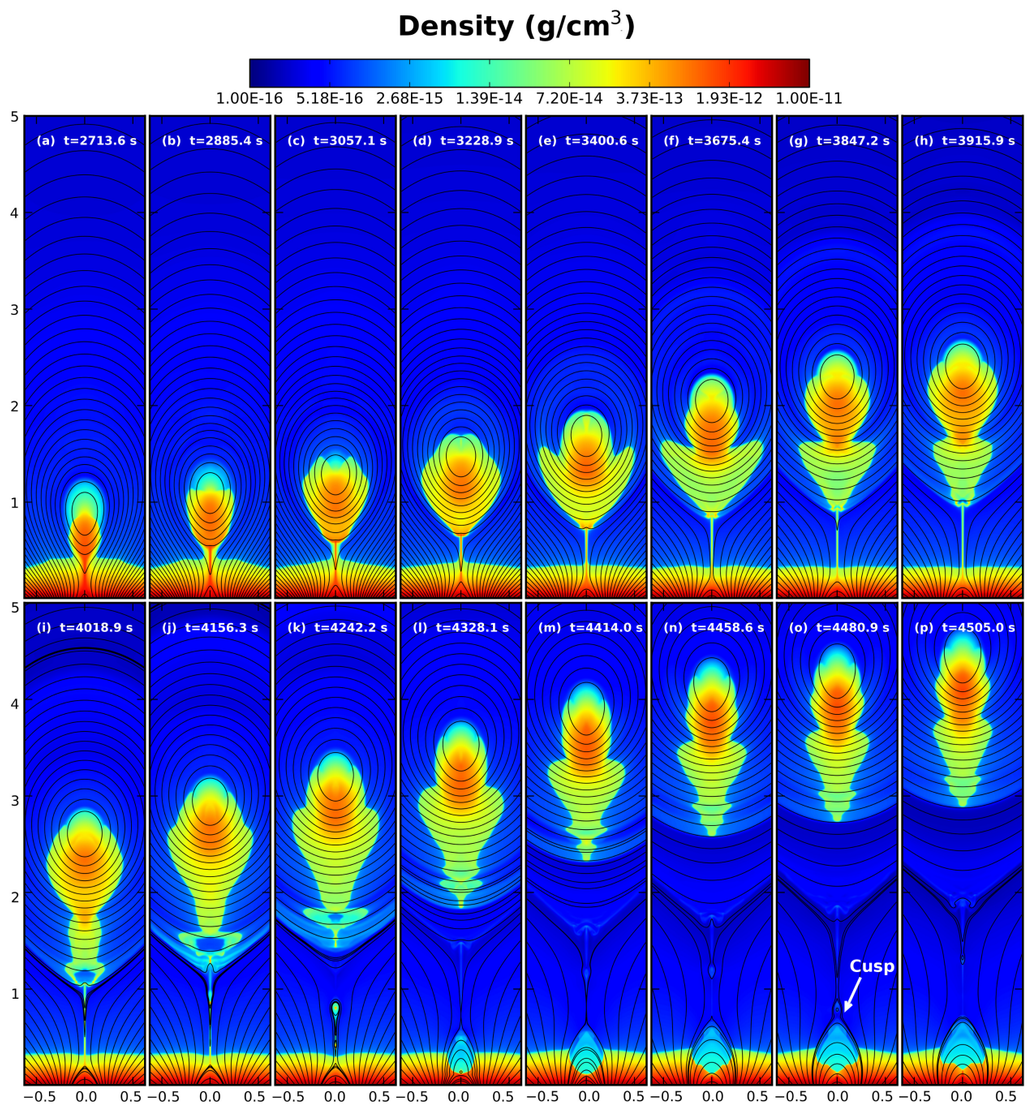
AI Flux rope formation driven by converging flow

A two-and-a-half-dimensional magnetohydrodynamic (MHD) simulation is conducted in a chromosphere-transition-corona setup. The linear force-free magnetic arcade is driven by an imposed slow motion converging toward the magnetic inversion line at the bottom boundary. The convergence brings opposite-polarity magnetic flux to the inversion line, leading to the formation of a flux rope by magnetic reconnection. The flux rope erupts and lifts mass from the chromosphere to the corona. The figure below illustrates the flux rope formation driven by photospheric converging motion.



AII Flux rope eruption & mass lifting

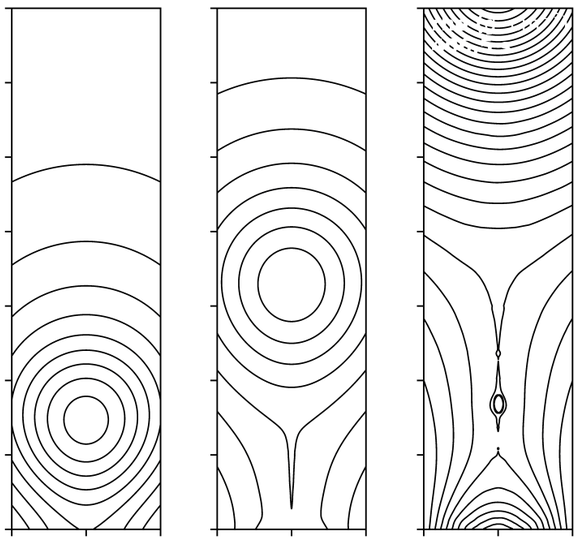
The evolution of density of the current sheet with magnetic field lines overlaid is shown below, illustrating prominence formation by levitation.



(B) Reconnection-condensation model

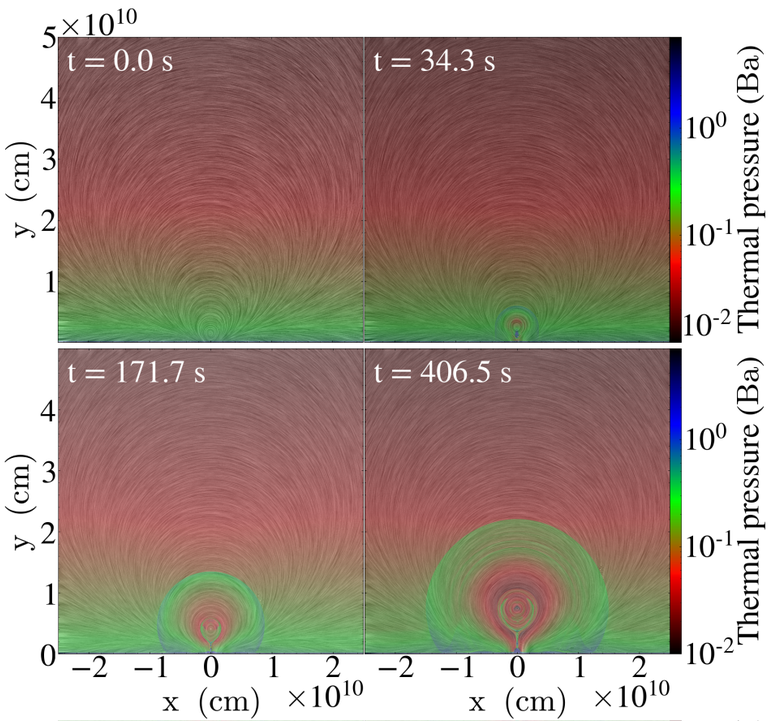
BI Flux rope eruption due to catastrophe

A flux rope has already existed in the low corona. The flux rope erupts due to catastrophe.The flux rope stretches the magnetic field lines and an current sheet formed underneath. Multiple magnetic islands appear after the resistive instabilities start. The islands carry mass from the chromosphere into the flux rope.



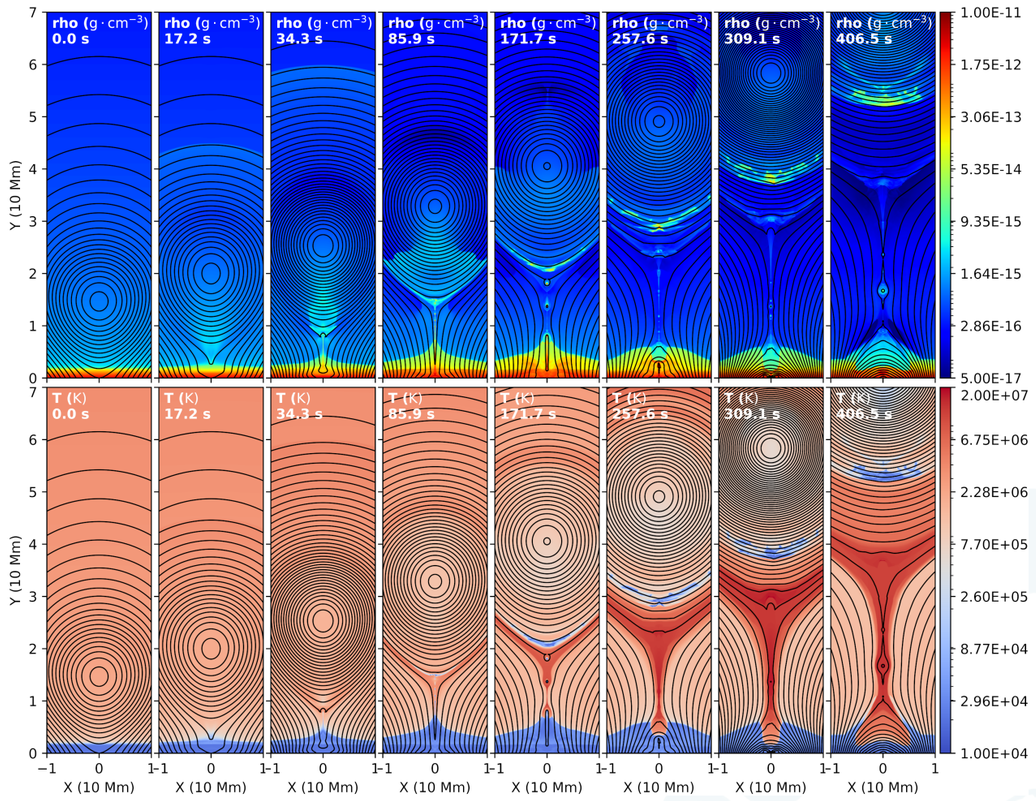
BII Global evolution

Thermal pressure evolution of the whole simulation domain with magnetic field lines overlaid is shown. A bow shock is formed in front of the erupting flux rope. The magnetic islands take mass from the chromosphere into the flux rope.



BIII Island motion & prominence formation

The evolution of density (top) and temperature (bottom) of the current sheet with magnetic field lines overlaid is shown below, illustrating prominence formation by reconnection-condensation.



References for model A

Zhao, X., & Keppens, R. 2020, ApJ, 898, 90
Zhao, X., Xia, C., Keppens, R., & Gan, W. 2017, ApJ, 841, 106
Zhao, X., Xia, C., Van Doorsselaere, T., Keppens, R., & Gan, W. 2019, ApJ, 872, 190

References for model B

This model is a new model proposed by the authors, which is not reported in any literatures.

Summary and comparison

We reproduce two potential models, i.e., the levitation model and the reconnection and condensation model, by two-and-a-half-dimensional MHD simulations in a chromosphere-transition-corona setup.

Comparison	Levitation	Reconnection and condensation
Flux rope	Created by converging motion	Pre-existing
Prominence mass	The mass is lifted by the flux rope	The mass is carried into the flux rope by islands
Condensation	No condensation	Hot material from the low corona lifted by the flux rope cools down and condenses into the prominence