4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Levitation-condensation prominence formation at extreme resolutions

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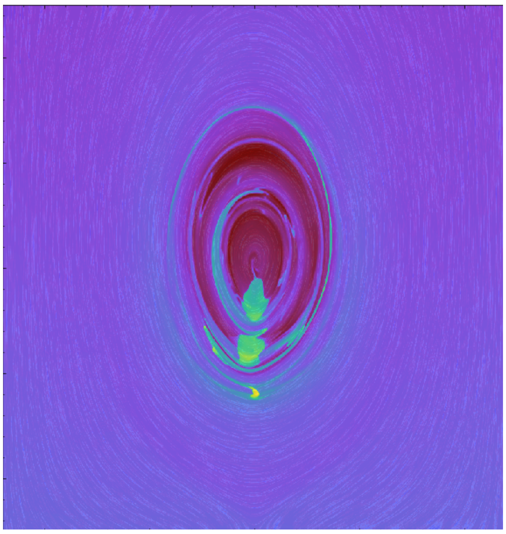

Following up on pioneering work presented in [1], we revisit the so-called levitation-condensation means for forming solar prominences: cool and dense clouds in the million-degree solar atmosphere. Levitation-condensation occurs following the formation of a flux rope through the deformation of a force-free coronal arcade by controlled magnetic footpoint motions. Existing coronal plasma gets lifted within the forming rope, therein isolating a collection of matter now more dense than its immediate surroundings. This denser region ultimately suffers a thermal instability driven by radiative losses, and a prominence forms. We improve on various aspects that were left unanswered in the original work, by revisiting this model with our modern open-source grid-adaptive simulation code [amrvac.org, see [2]]. Most notably, this tool enables unprecedented resolutions, down to 5.6 km details within a 24 Mm x 25 Mm domain size. Our 2.5D simulation (where the flux rope has realistic helical magnetic field lines) demonstrates that the thermal runaway condensation can happen in multiple places, not solely in the bottom part of the flux rope where most material is condensing in-situ. Intricate thermodynamic evolutions and shearing flows develop spontaneously, themselves inducing further fine-scale (magneto)hydrodynamic instabilities. Our analysis makes explicit links with advanced linear magnetohydrodynamic stability theory, e.g. with the Convective Continuum Instability or CCI process [3] as well as with in-situ thermal instability studies [4]. We find evidence for reconnection-driven dynamics in the prominence body, in close analogy with analytical predictions [5]. These findings are relevant for modern studies of full 3D prominence formation [e.g., 6], where the challenge to reach similar effective resolutions is daunting.

References

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