Expected signatures of prominence condensation and eruption

T. Kaneko (Nagoya Univ.)

Collaborators: T.Yokoyama (UTokyo), K.Kusano (Nagoya Univ.)

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Introduction

Astrophysical condensation (thermal instability)

• Interstellar medium

Warm medium \longrightarrow Molecular cloud(temperature: 10^4)(temperature: < 100 K)</td>

Time scale \sim million years

• Solar atmosphere

Corona \longrightarrow Prominence, Coronal rain(temperature: 10^6 K)(temperature: $< 10^4$ K)

Time scale \sim hours to days

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Observation of solar condensation

Berger et al. (2012)



Temporal intensity shift from high temperature to low temperature -> Radiative condensation

No spectroscopic information ->Velocity & mass flux were unclear



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Numerical modeling of condensation

Numerical modeling prominence formation via condensation (and eruption)

reconnection-condensation model (Kaneko & Yokoyama, 2015, 2017) + flare trigger model (Kusano et al., 2012)

Prediction of characteristics of condensation flows

- Where ? Which temperature ?
- Can we distinguish them from turbulent flows (±5km/s)?



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Numerical settings: basic equation

$$\begin{split} \frac{\partial \rho}{\partial t} + \nabla \cdot (\rho v) &= 0, \\ \frac{\partial (\rho v)}{\partial t} + \nabla \cdot \left(\rho v v + pI + \frac{B^2}{8\pi} I - \frac{BB}{4\pi} \right) - \rho g &= 0, \\ \frac{\partial}{\partial t} \left(e_{th} + \frac{1}{2} \rho v^2 + \frac{B^2}{8\pi} \right) + \nabla \cdot \left[\left(e_{th} + p + \frac{1}{2} \rho v^2 \right) v + \frac{c}{4\pi} E \times B \right] \\ &= \rho g \cdot v + \nabla \cdot \left(\kappa T^{5/2} b b \cdot \nabla T \right) - n^2 \Lambda(T) + H, \\ \text{conduction radiative heating } \\ e_{th} &= \frac{p}{\gamma - 1}, \quad T = \frac{m}{k_B} \frac{p}{\rho}, \end{split}$$

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Initial & boundary condition



Initial state

Grid spacing size: 120 km

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Overview of simulation result



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Supersonic condensation flow

Mach number = 1^2

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condensation flow:

- supersonic (Mach 1 2)
- narrow region (< 300km)
- transient (several ~20 min)
- multi-thermal

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condensation flow:

- supersonic (Mach 1~2)
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Collaboration with IRIS or EUVST ?



condensation flow:

- supersonic (Mach 1~2)
- narrow region (< 300km)
- transient (20 min)

Shock interaction in prominence

✓ Heating (?)

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Eruption

Result of parameter survey



High density -> Enhancement of magnetic free energy

Condensation is coupled with eruptive mechanism.

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Can we detect both condensation and eruption ?

→ Miniature filament eruptions (Wang et al., 2000; Sterling et al, 2015)

1 hour from formation (condensation?) to eruption

High occurrence frequency in quiet region

Narrow FOV is OK

- supersonic (Mach 1-2)
- narrow region (< 300km)
- transient (20 min)
- multi-thermal $(10^4 10^5)$

Condensation to Eruption:

- Miniature filaments are practical targets.
- Free energy enhanced by prominence ?



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