Multi-Temperature Mass Ejections from Stellar Flares on a Young Solar Analogue

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11:20-11:35 (15 min), September 3, 2025 (Wed)
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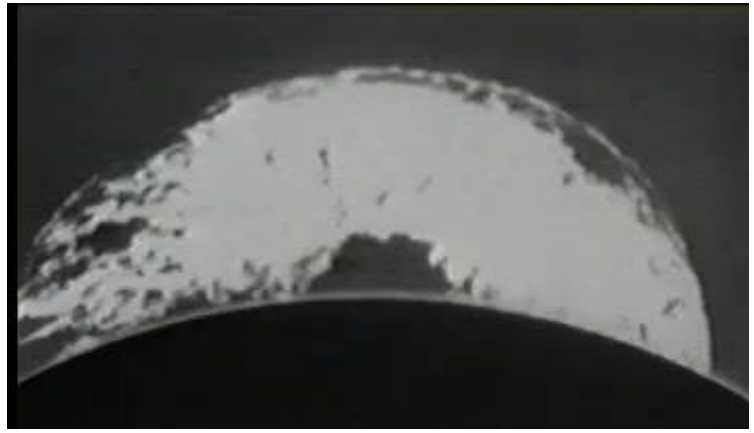
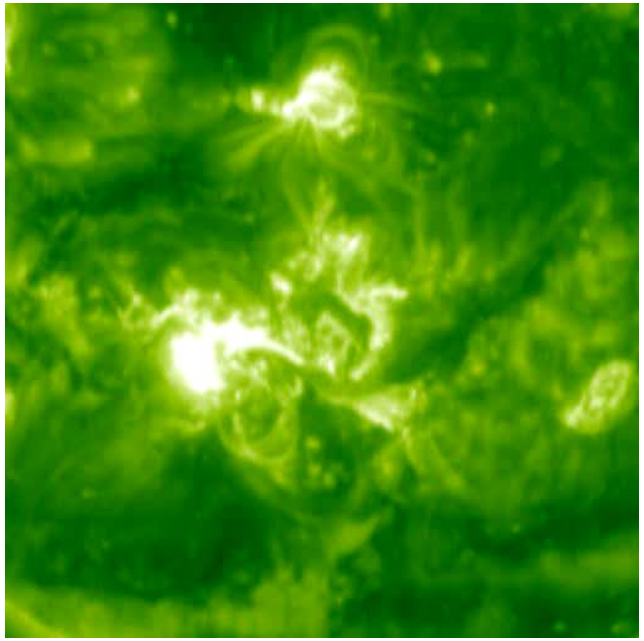
Solar flares/CMEs

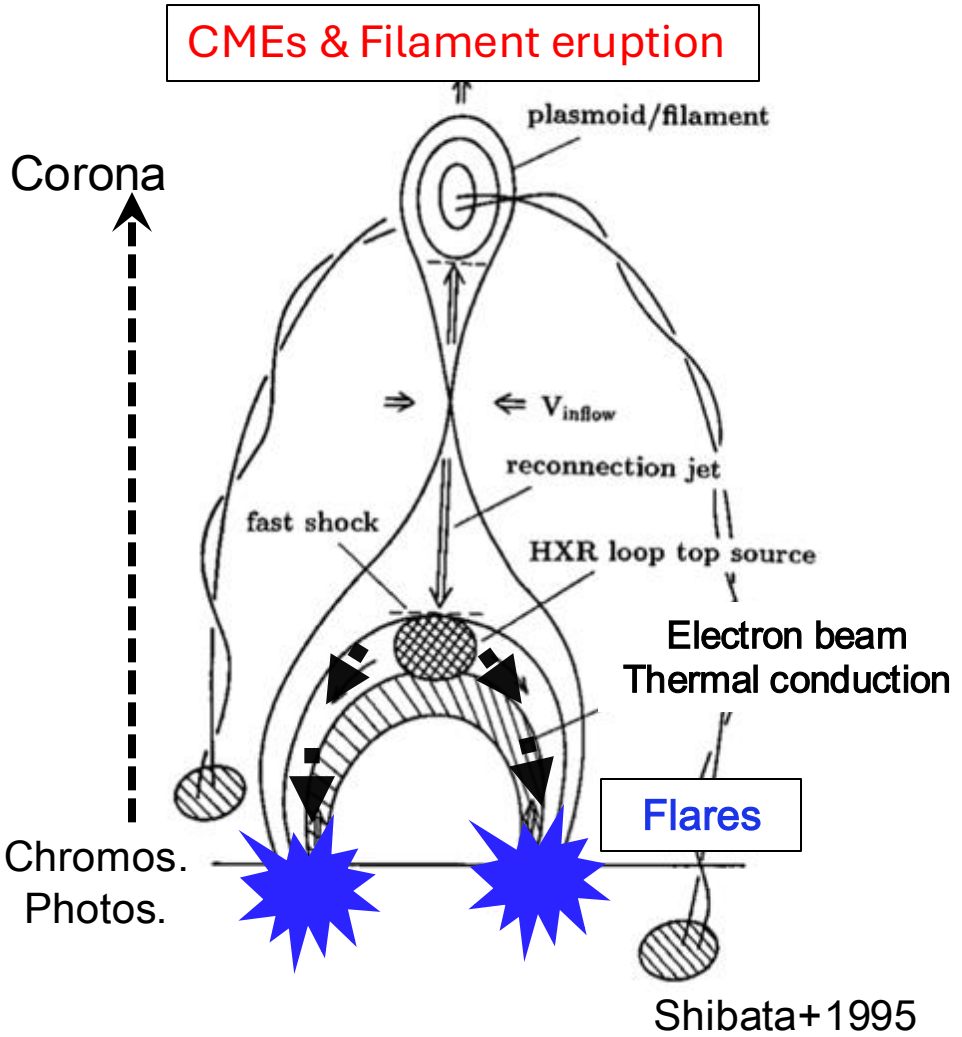
- Solar flares are often associated with Coronal Mass Ejections (CMEs)
- They often affect the planetary environment
- **Our interest: How about other star-planet systems?**
  - ✓ Stellar CME can impact chemistry change and escape of exoplanetary atmospheres [e.g. Airapetian+ 20]
  - ✓ But occurrence of stellar CMEs are mostly unknown



(©HAO)



Unified picture of solar flares, filament eruptions, and CMEs



Shibata+1995

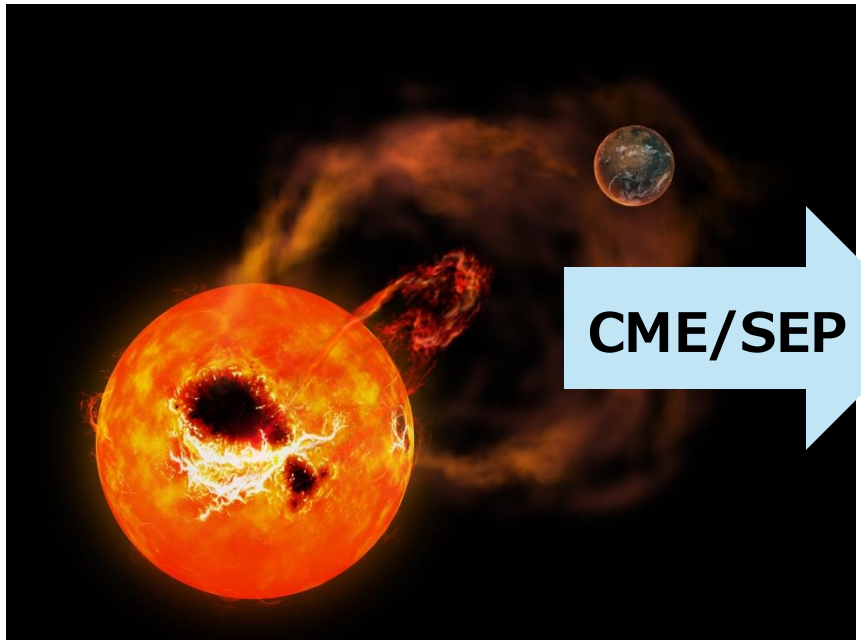
Young Sun-like Stars: Unique Window to the Young Sun

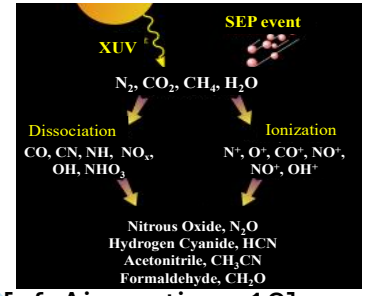
- Young Sun-like star (G-dwarf) is important as
  - ✓ As hosts of young exoplanets & as proxy of “the young Sun”
  - ✓ At the age when formation of atmosphere is occurring (50-300 Myr)

- Known: Young Sun-like stars are super-active, producing “superflares” (>10^{33} erg)

  → Question: Can they produce huge CMEs/SEPs?

  Do they play significant roles in planet atmosphere?





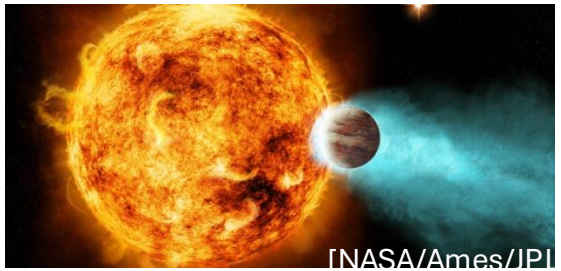
[cf. Airapetian+16]

Stellar mass & angular momentum evolution

[Cranmer+17]

No observation of CMEs had been obtained before

Erosion **Aurora**



[cf. Hazra & Vidotto+22]

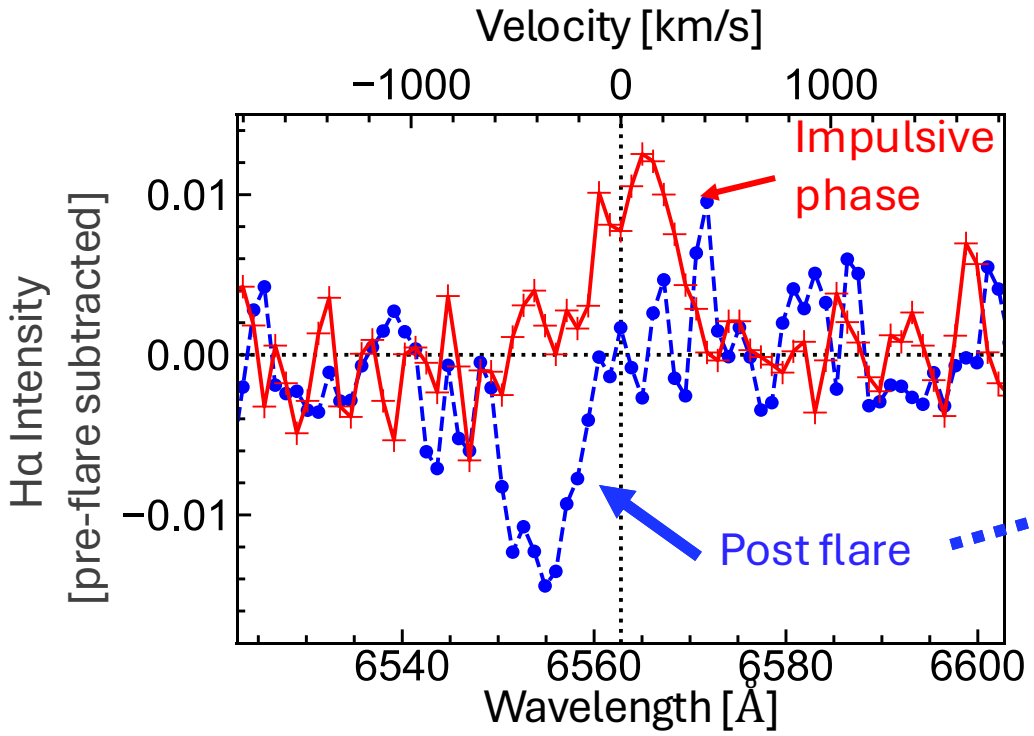
Discovery of a CME signature from young Sun-like star

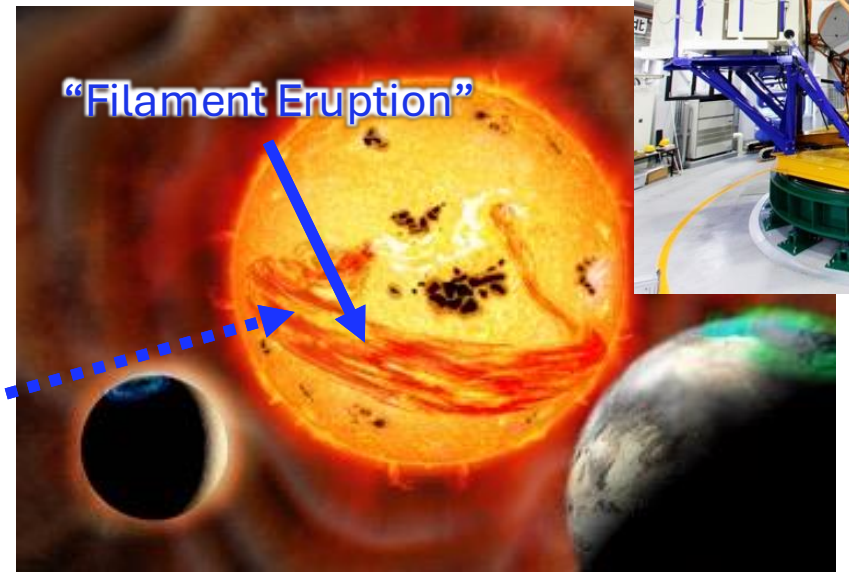
- We detected **a blueshifted Hα absorption** from a superflare on a young Sun-like star, EK Dra, by using Seimei/KOOLS-IFU

  ⇒ First discovery of a massive CME signature

[Namekata K.+ 2022 (2021 on ADS) Nature Astronomy, 6, 241,
Namekata K.+ 2022, ApJ Letters, 926, 5]

- Frequency ~ 1 events / 5 days [Namekata K.+ 2025, ApJ, accepted].



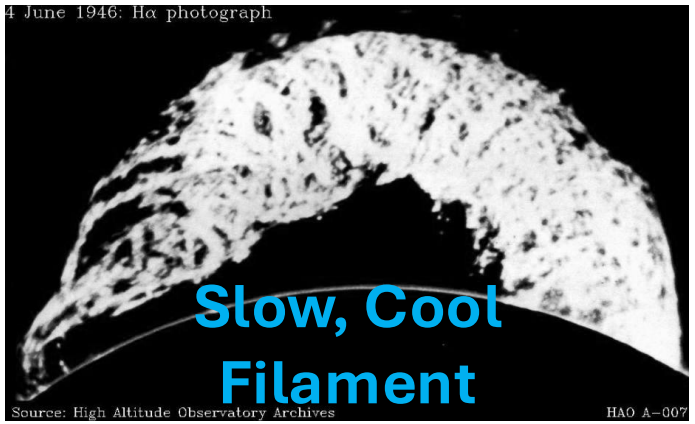


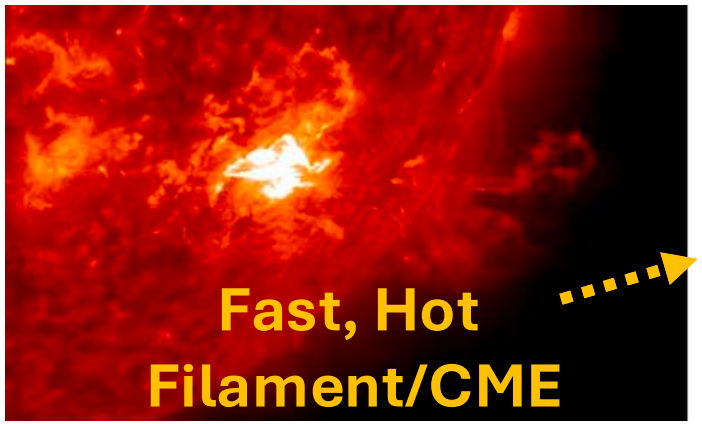
Imaginary picture of our findings (©NAOJ)

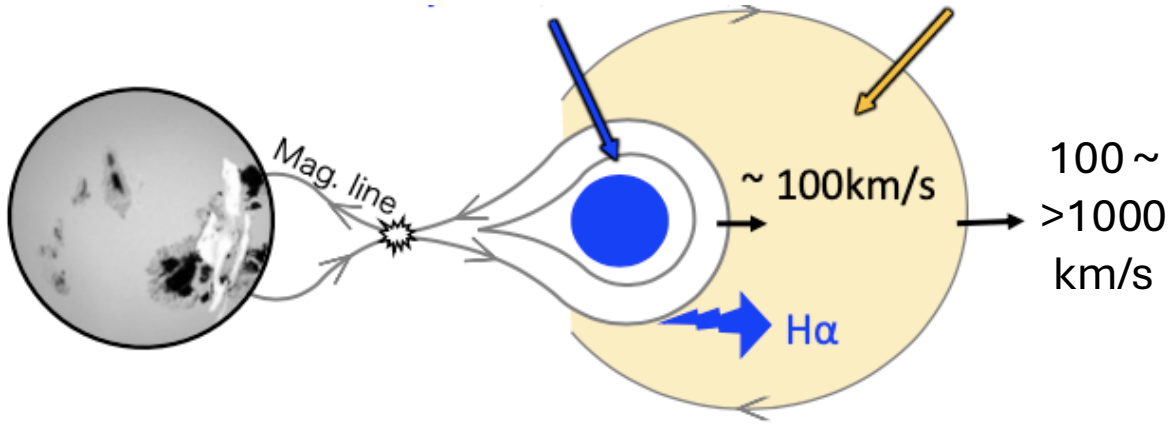
Needs for Multiwavelength Observations

- Solar observations say “CME is **multi-temperature & multi-structure**”
  “Hotter components are faster and therefore important for planets”

⇒ Hotter line spectr. obs. are required to constrain the model & assess its impact







- X-ray? ⇒ Ambiguity
(v.s. chromospheric evaporation)

- UV ⇒ Favorable (less ambiguous)

Needs for UV observations, together with H-alpha

(UV spectro. obs. have been limited because it relies on HST’s limited observing time.)

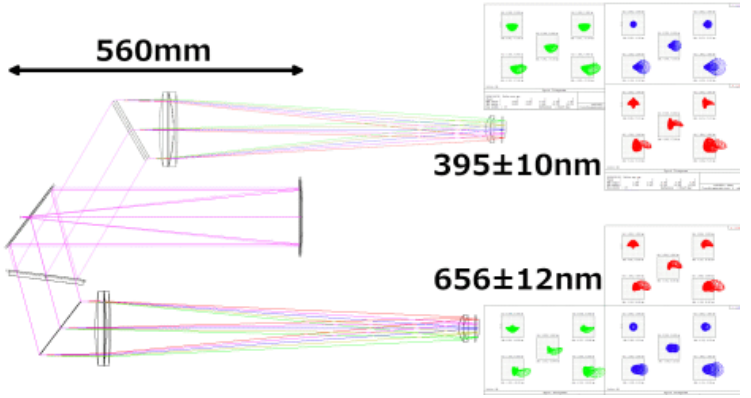
Summary & Future Direction

- **Result:** Our campaign with the HST and ground-based telescopes found multi-temperature CME/eruption signatures, for the first time on a star other than the Sun.

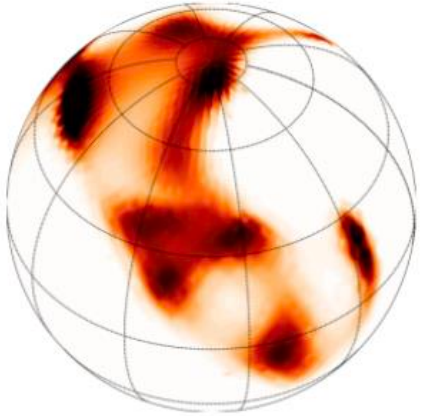
[Namekata K. et al. 2025 submitted]

- **Future Direction:**
  - ➢ This time, we missed blueshifts with Seimei/KOOLS-IFU due to the low spectral resolution. **⇒ Our new instrument "MIDSSAR" (2026A??) will be able to do it!!**
  - ➢ Simultaneous magnetic field mapping with GAOES-RV would determine the flare/CME location (cf. Namekata+24a, Lee et al. submitted), which will constrain the model.

Acknowledgement: Thanks to Prof. Minezaki for kindly exchanging his observing time with us, which enabled this campaign



MIDSSAR (H-alpha & Ca HK)
(see, Nogami-san's talk)



Spot map with GAOES-RV
(Lee et al. submitted)