Geometric Localization of CMEs Using COR2 Beacon Data

Curt A. de Koning, Vic Pizzo, Doug Biesecker

Introduction

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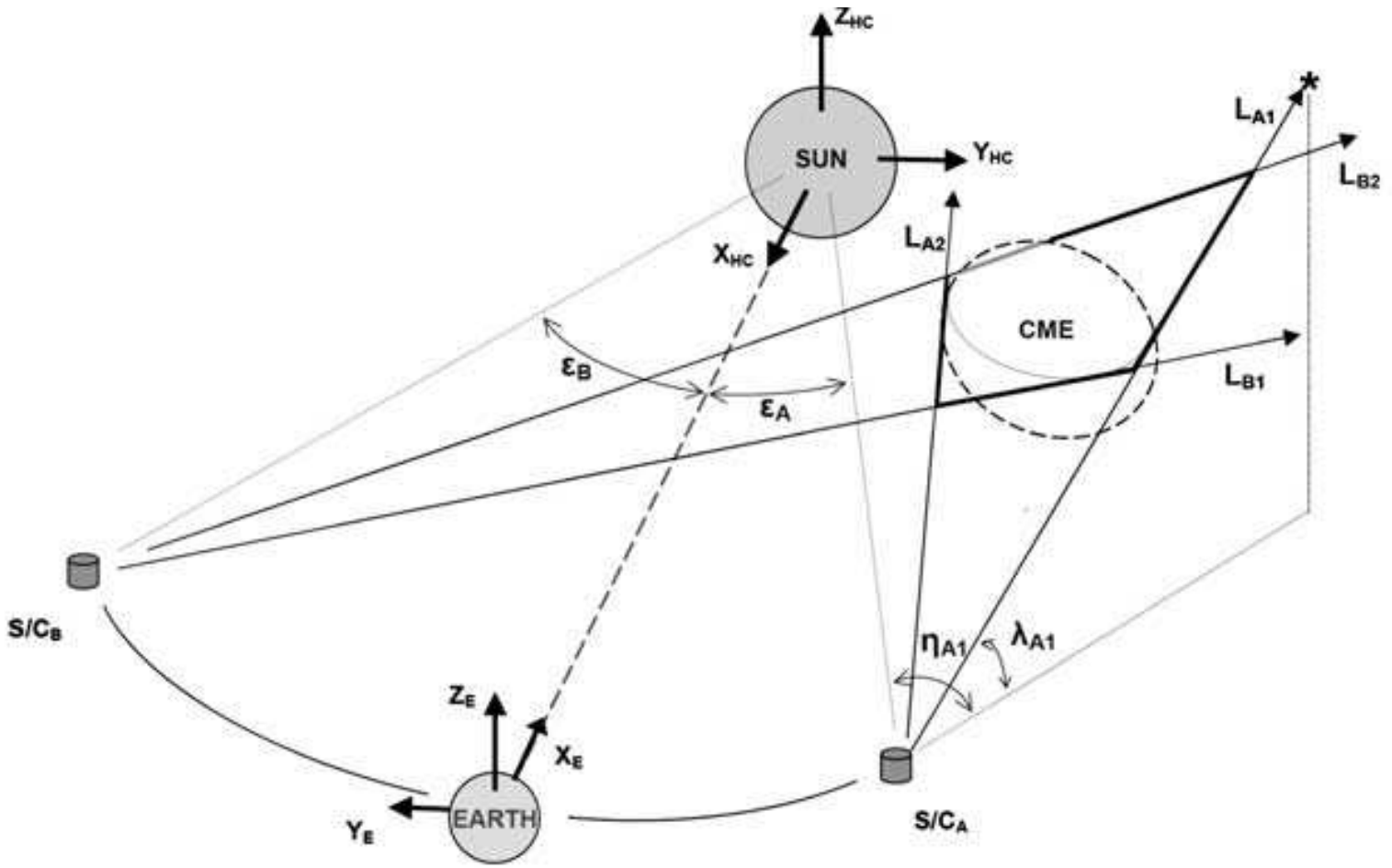
There is a need within the space weather community for a means to determine quickly and accurately the gross properties of Earth-directed CMEs. There is specific need for a near-real-time forecasting tool that can routinely and confidently be applied to the data stream from the STEREO Space Weather Beacon. Simplicity, robustness, and ease of use would be an issue, since the CME locater algorithm would have to run in automated or nearly automated mode within a forecast center.

Pizzo and Biesecker [2004] have developed a straightforward geometric localization methodology that meets the above requirements.



Schematic diagram showing geometry used to localize CMEs

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COR2 Observations from 21 August 2007

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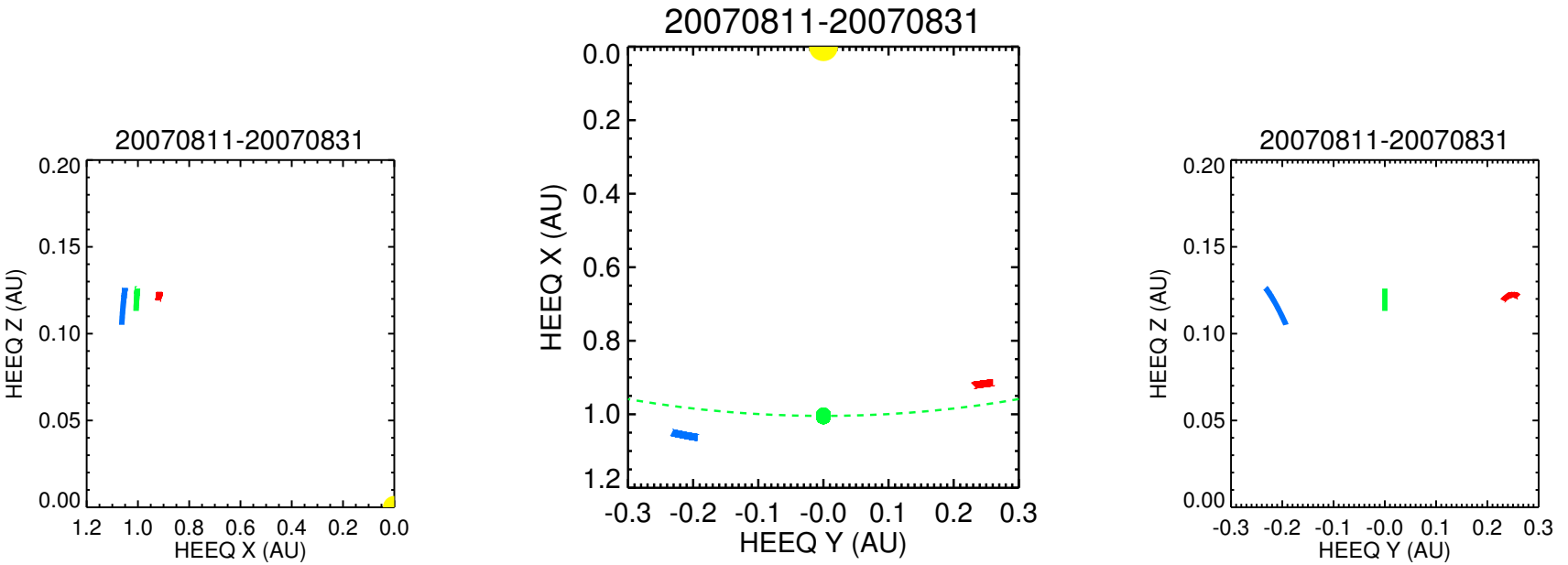

Position of STEREO-A, STEREO-B, and Earth on 2007-08-21

	A	E	B
Heliocentric radius (AU)	0.9576	1.0117	1.0847
Heliographic (HEEQ) longitude	15.030	0.000	-11.420
Heliographic (HEEQ) latitude	7.339	6.896	6.215
Separation angle with Earth	14.920		11.366
Separation angle A with B		26.286	

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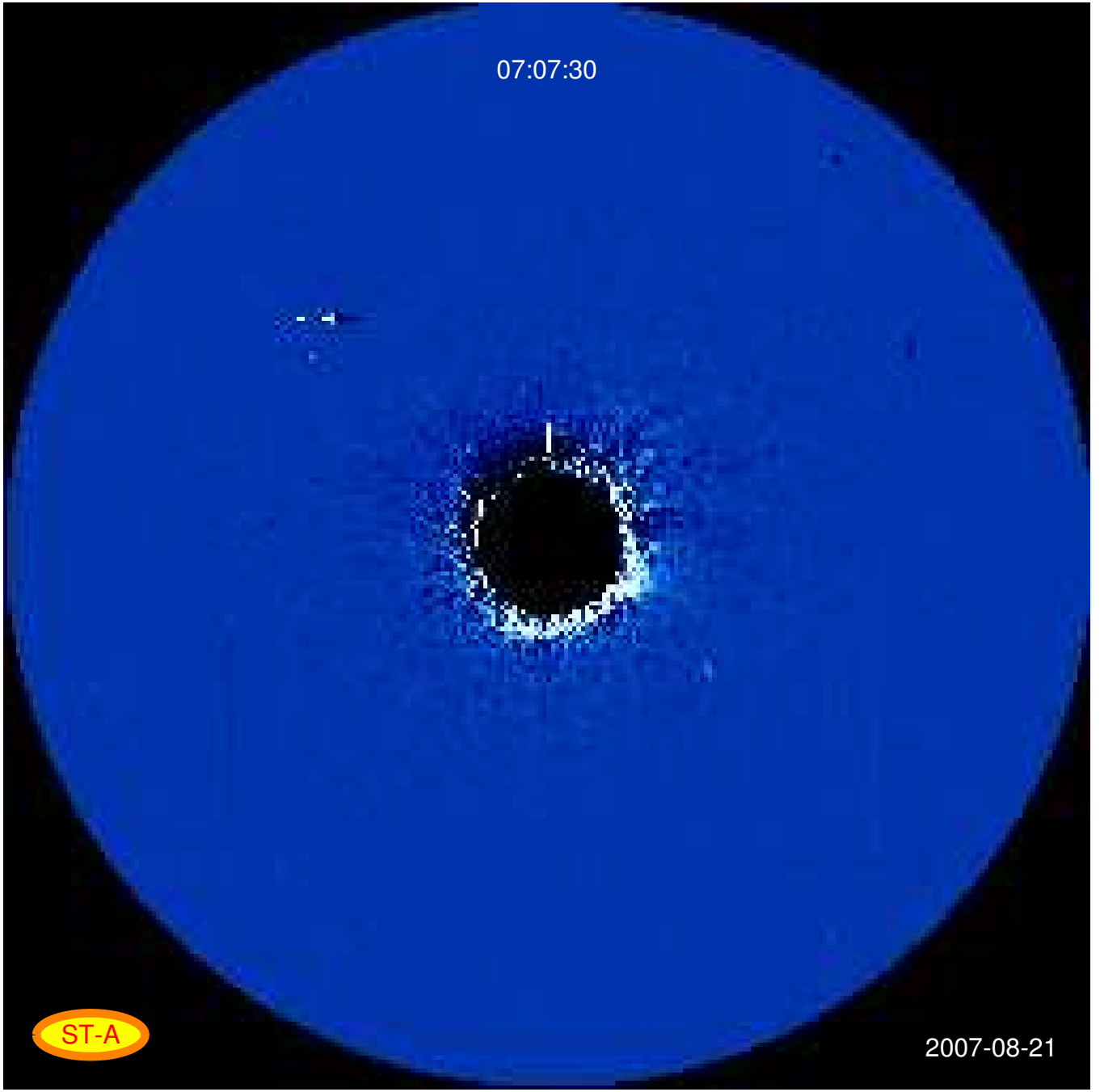
Geometric Localization



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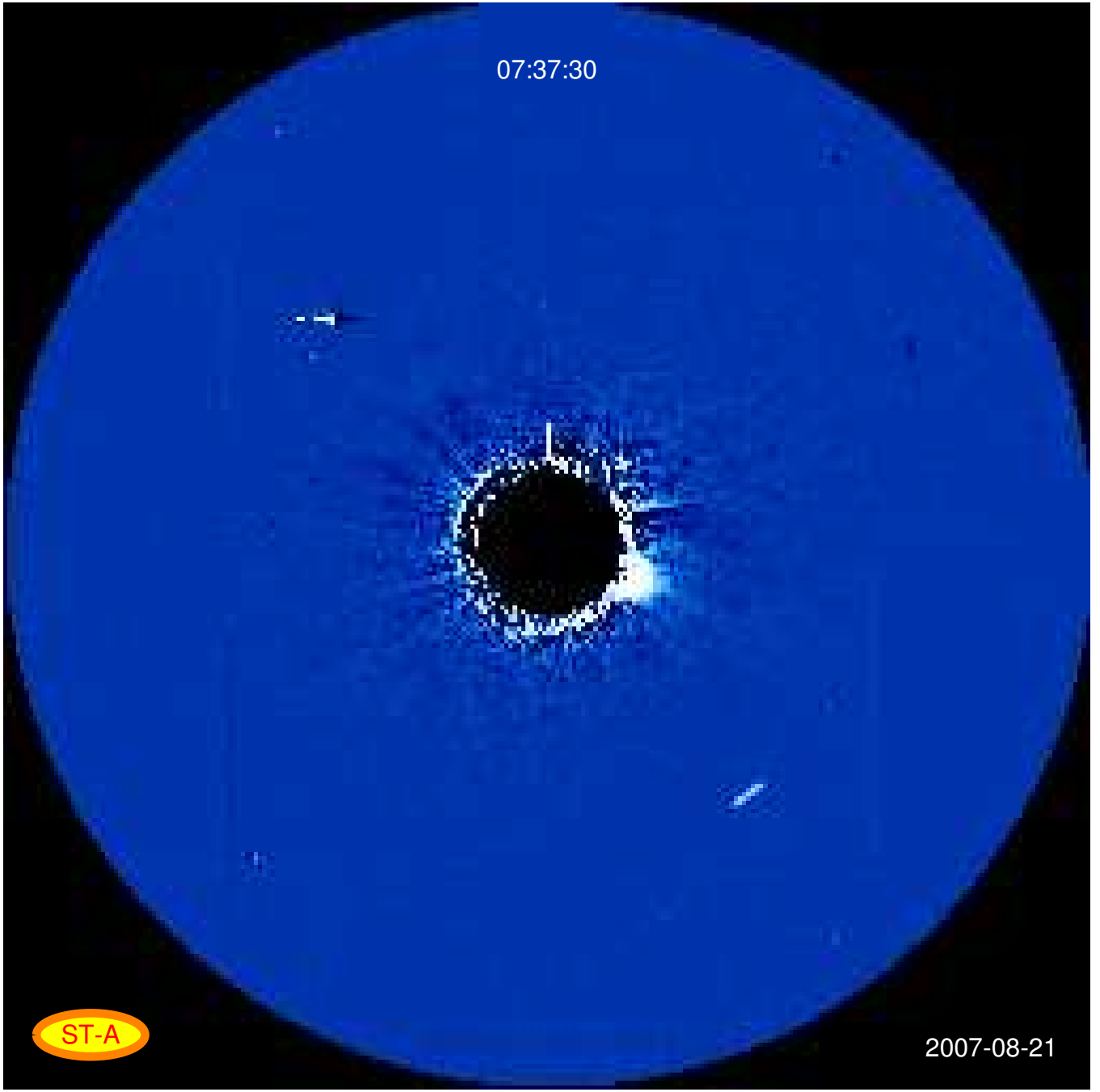

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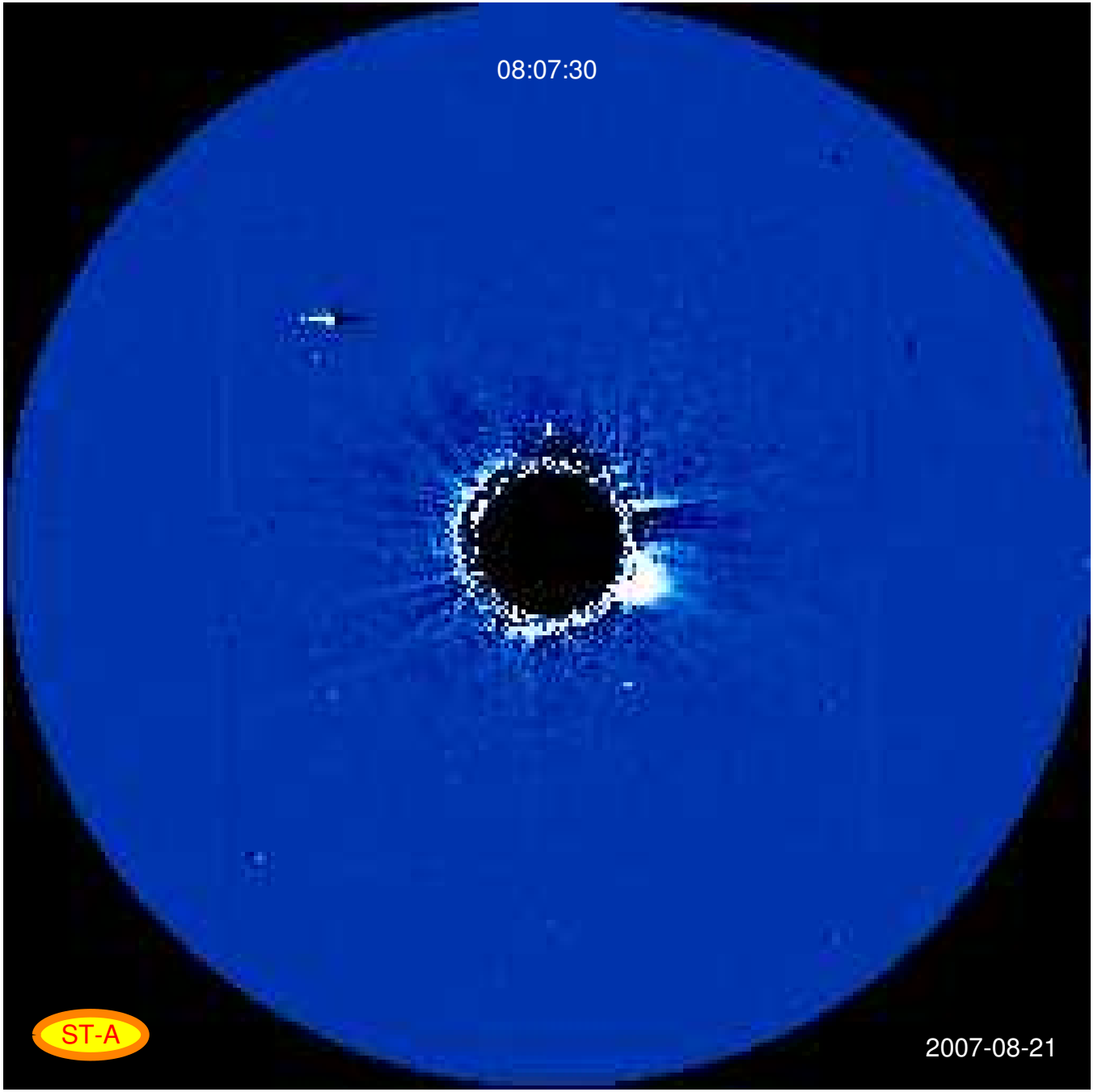

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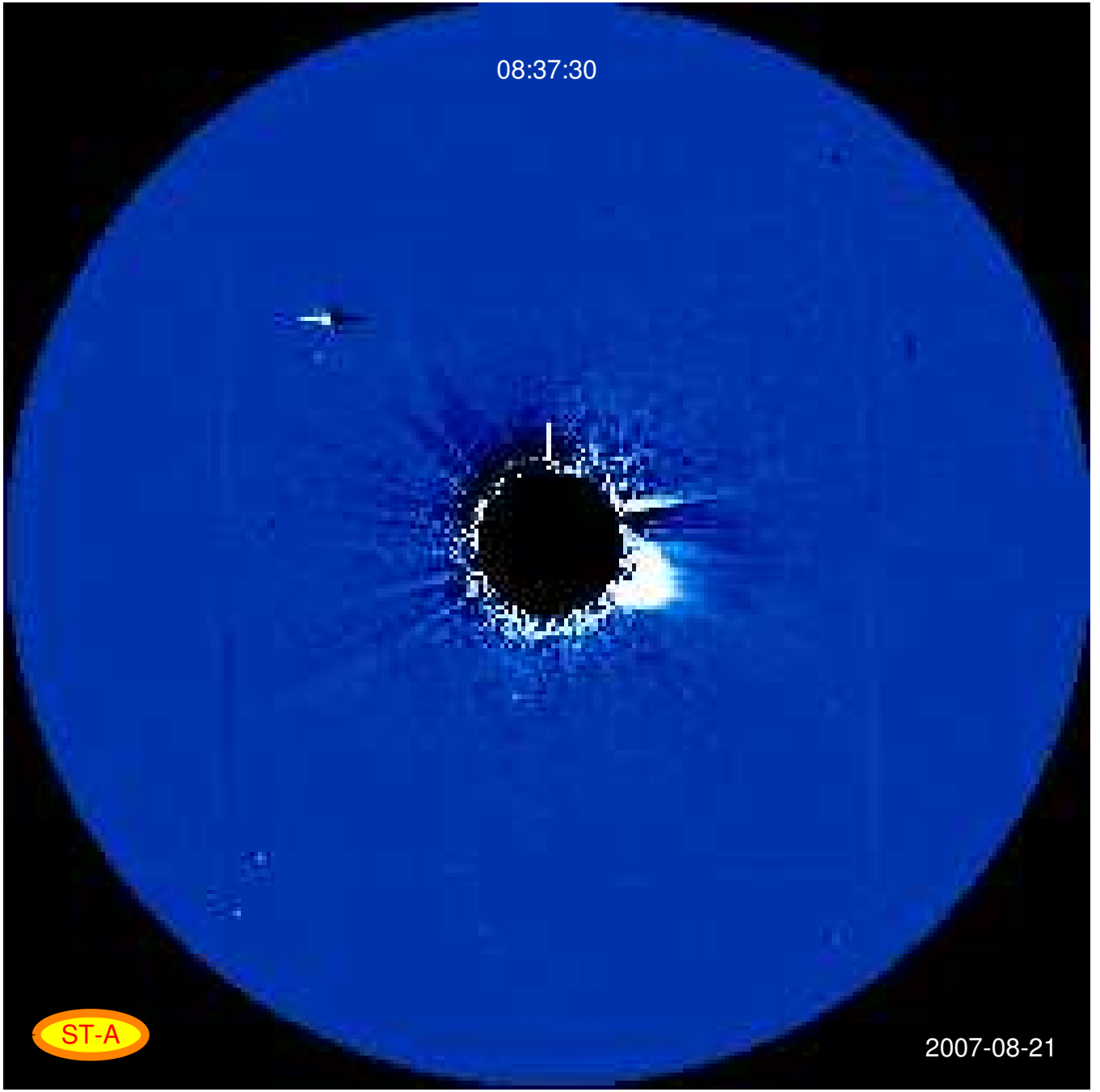

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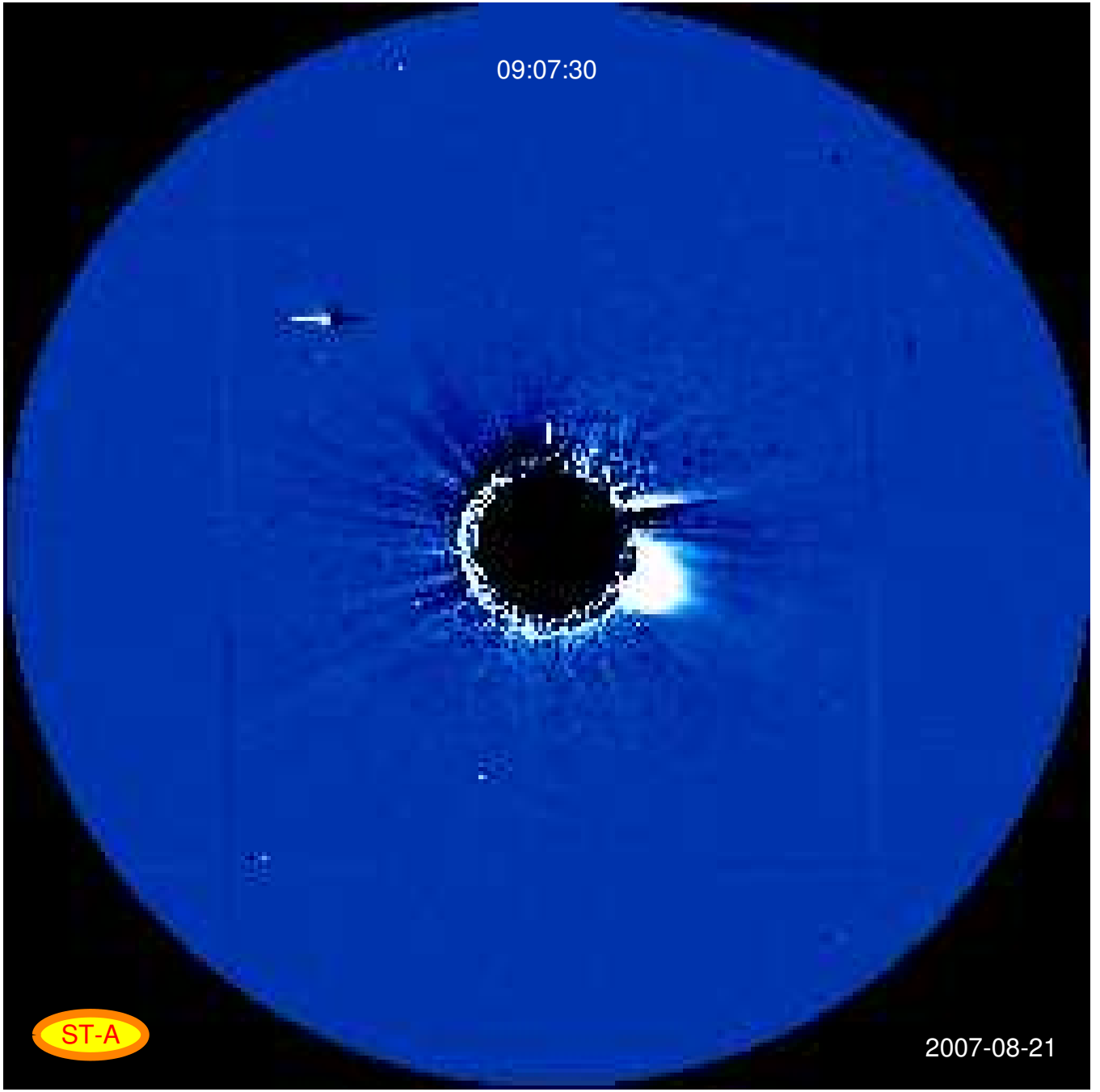

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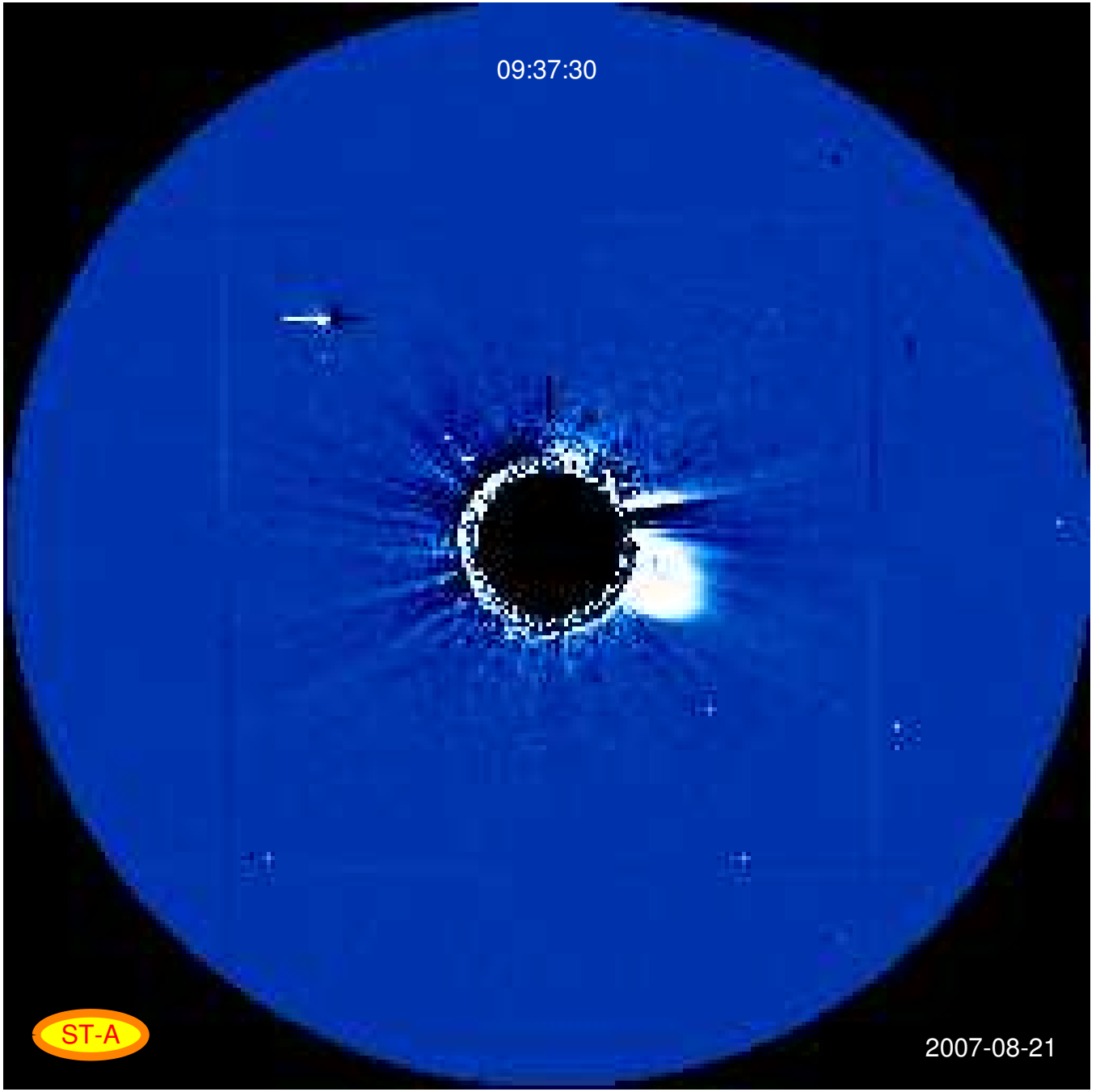

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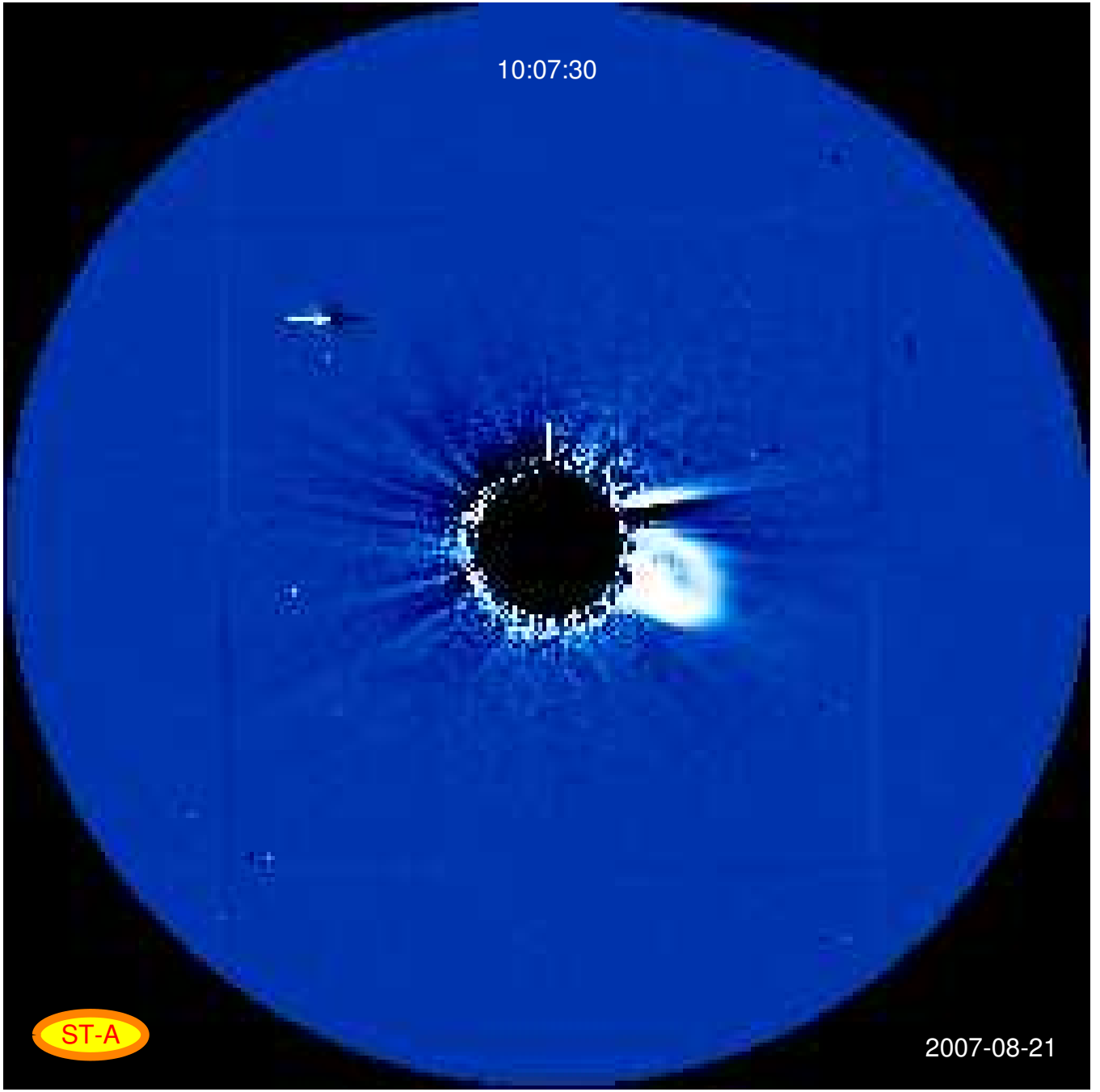

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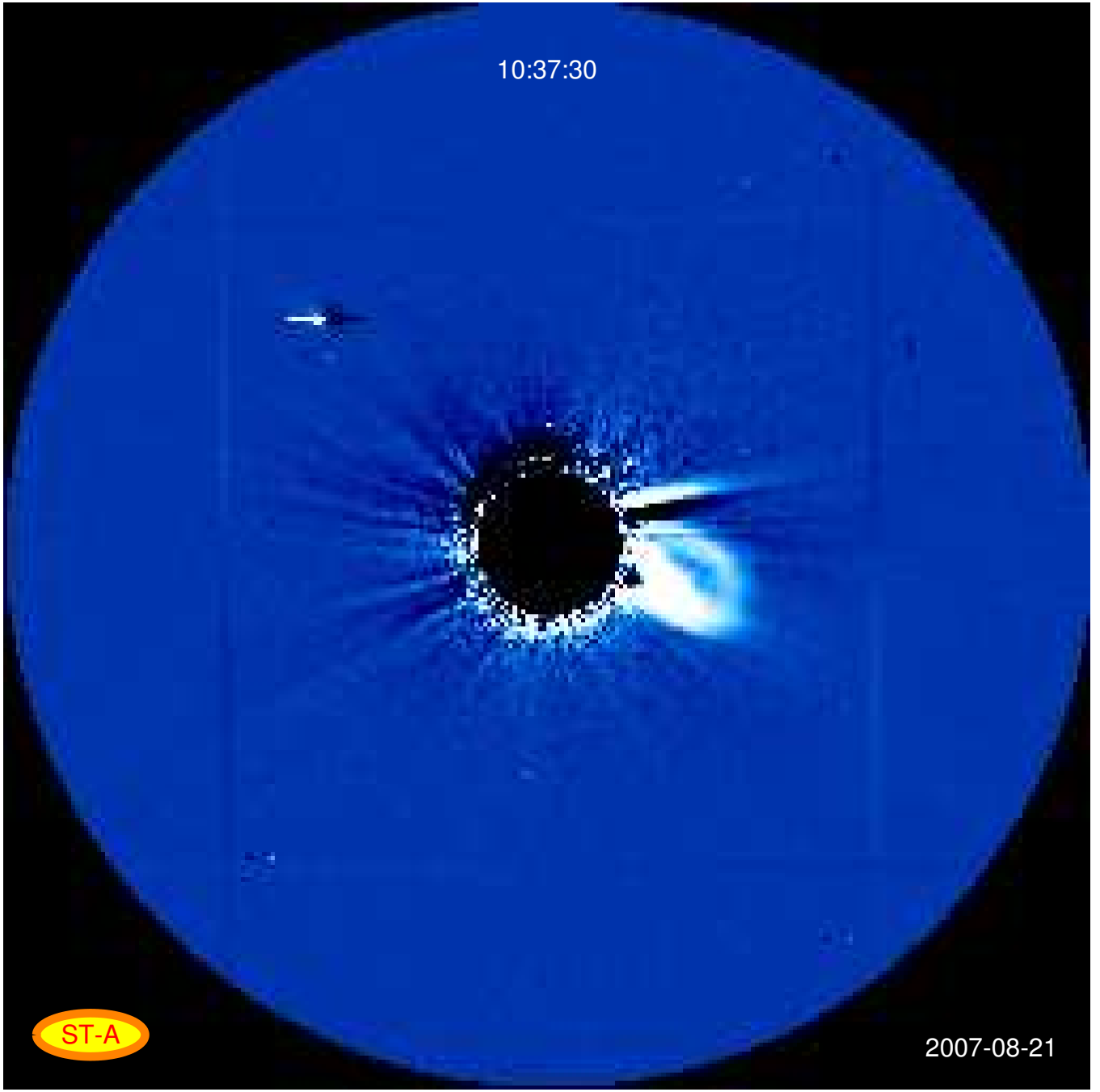

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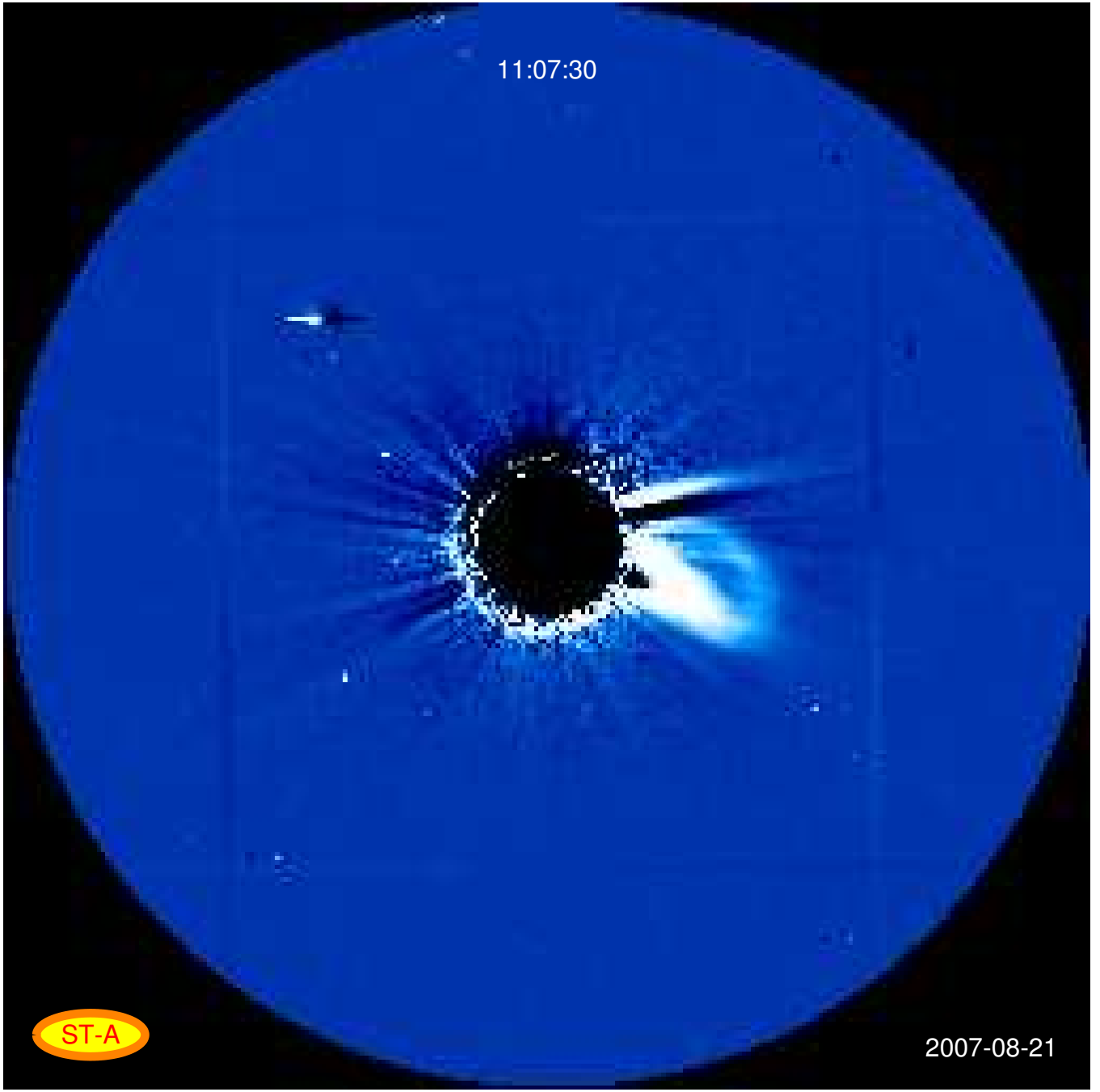

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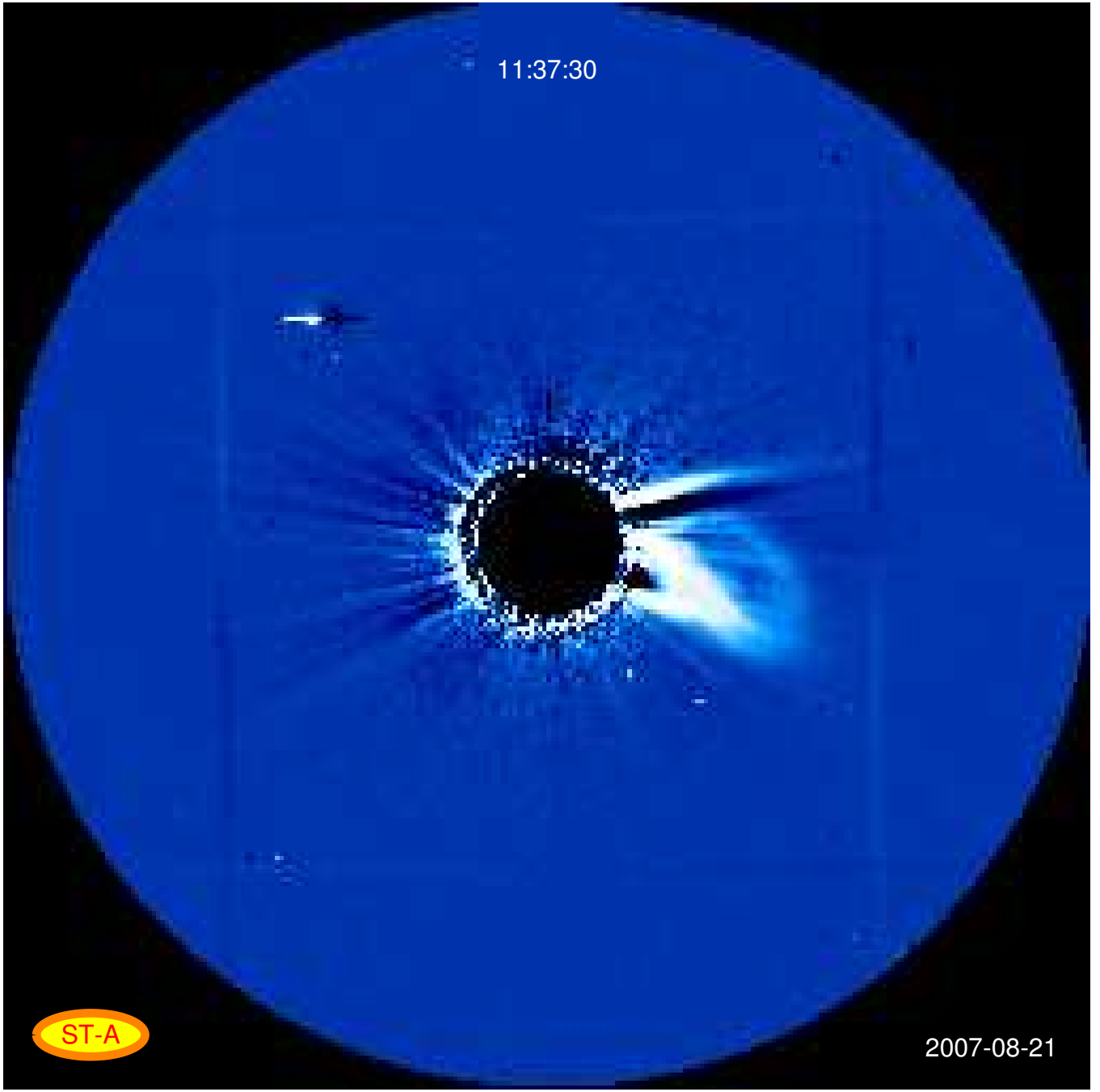

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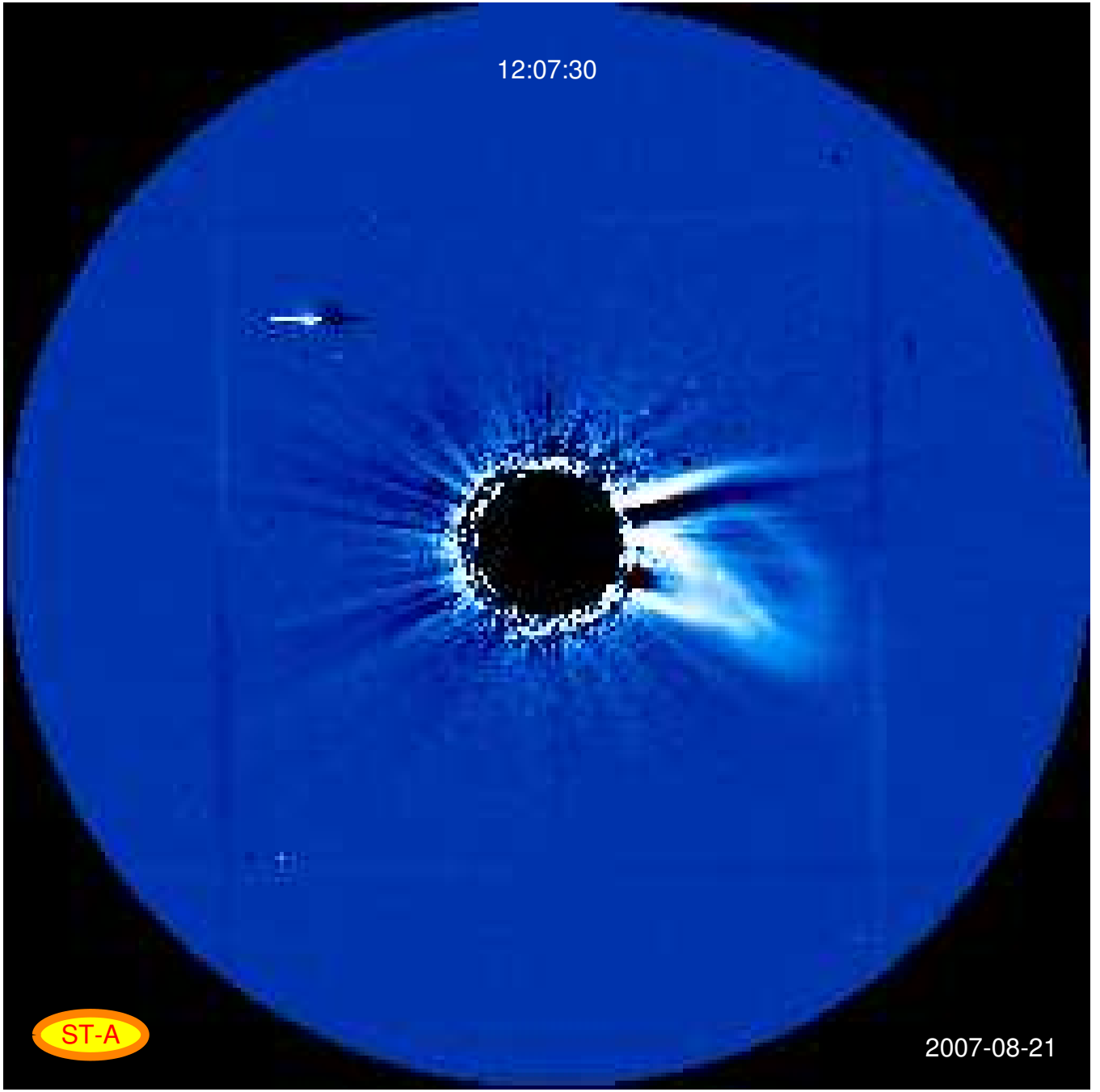

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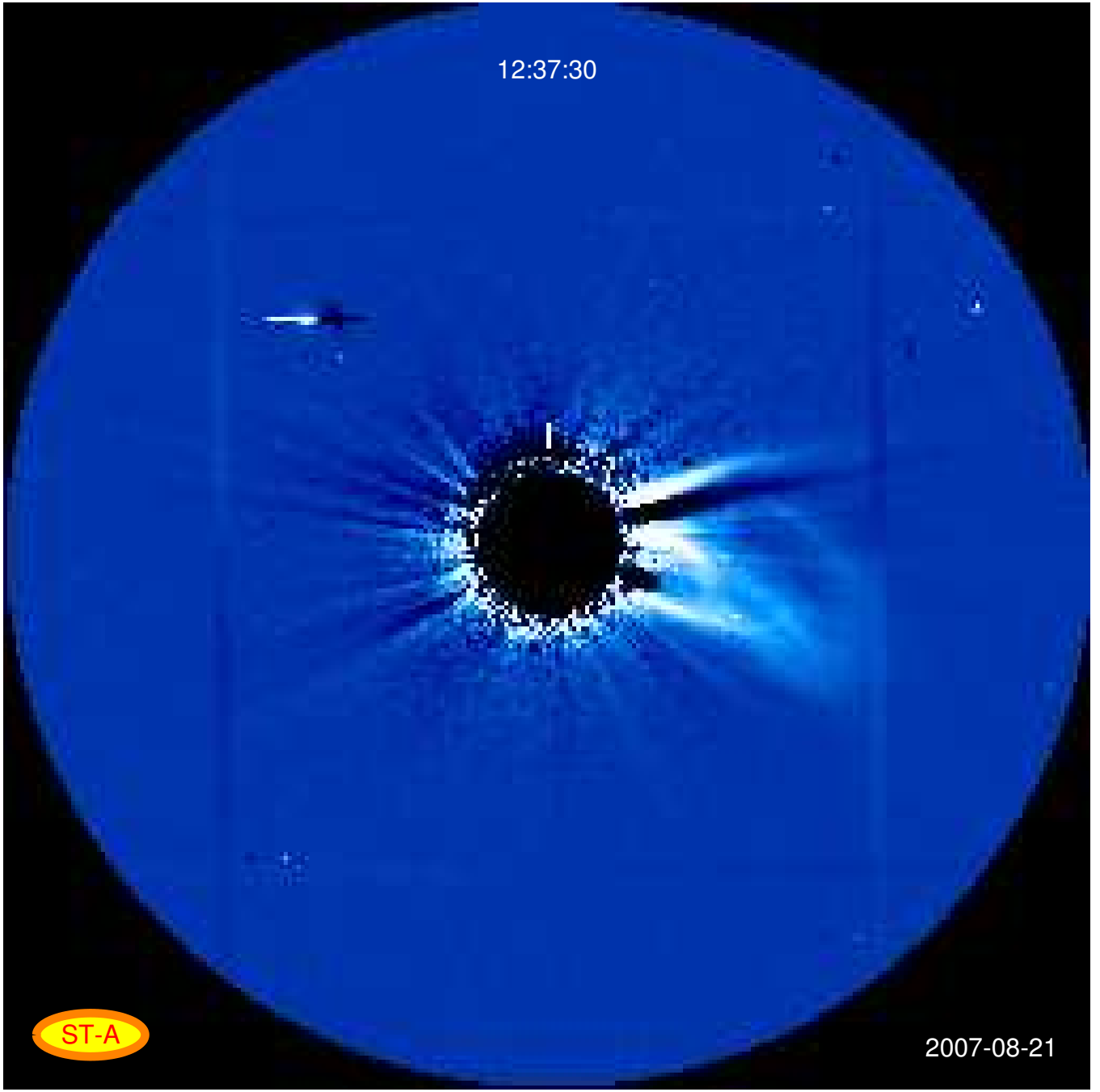

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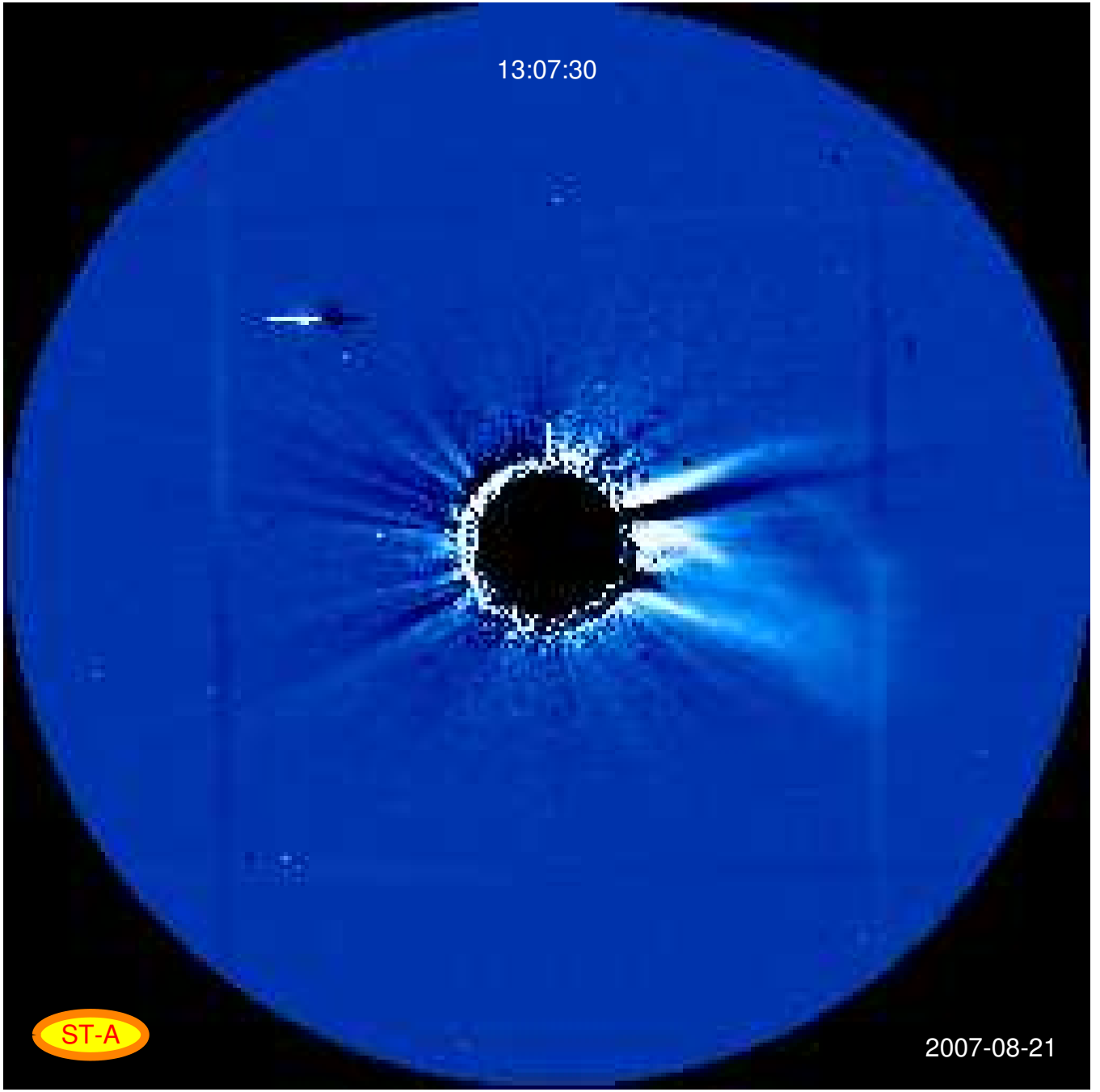

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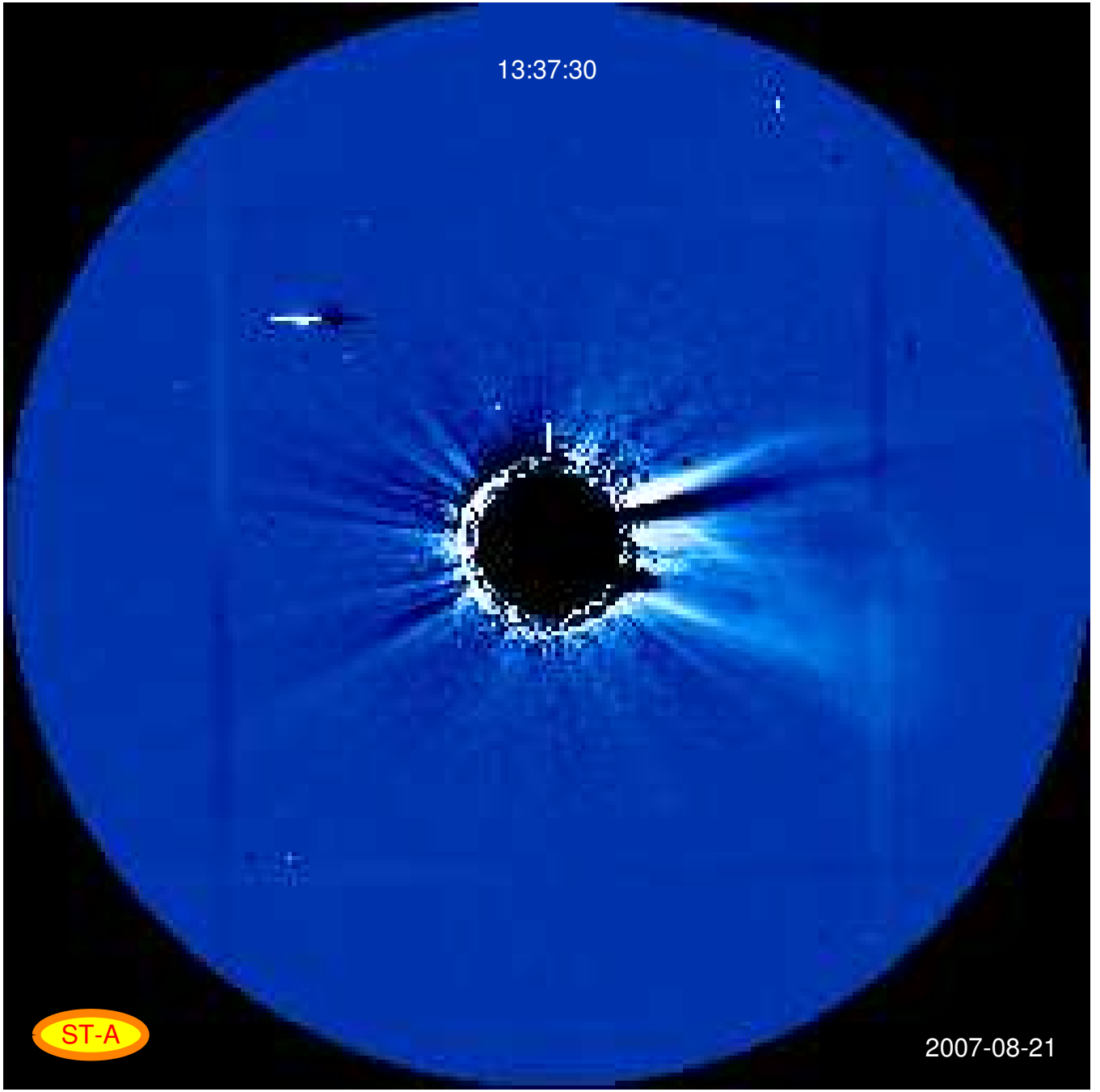

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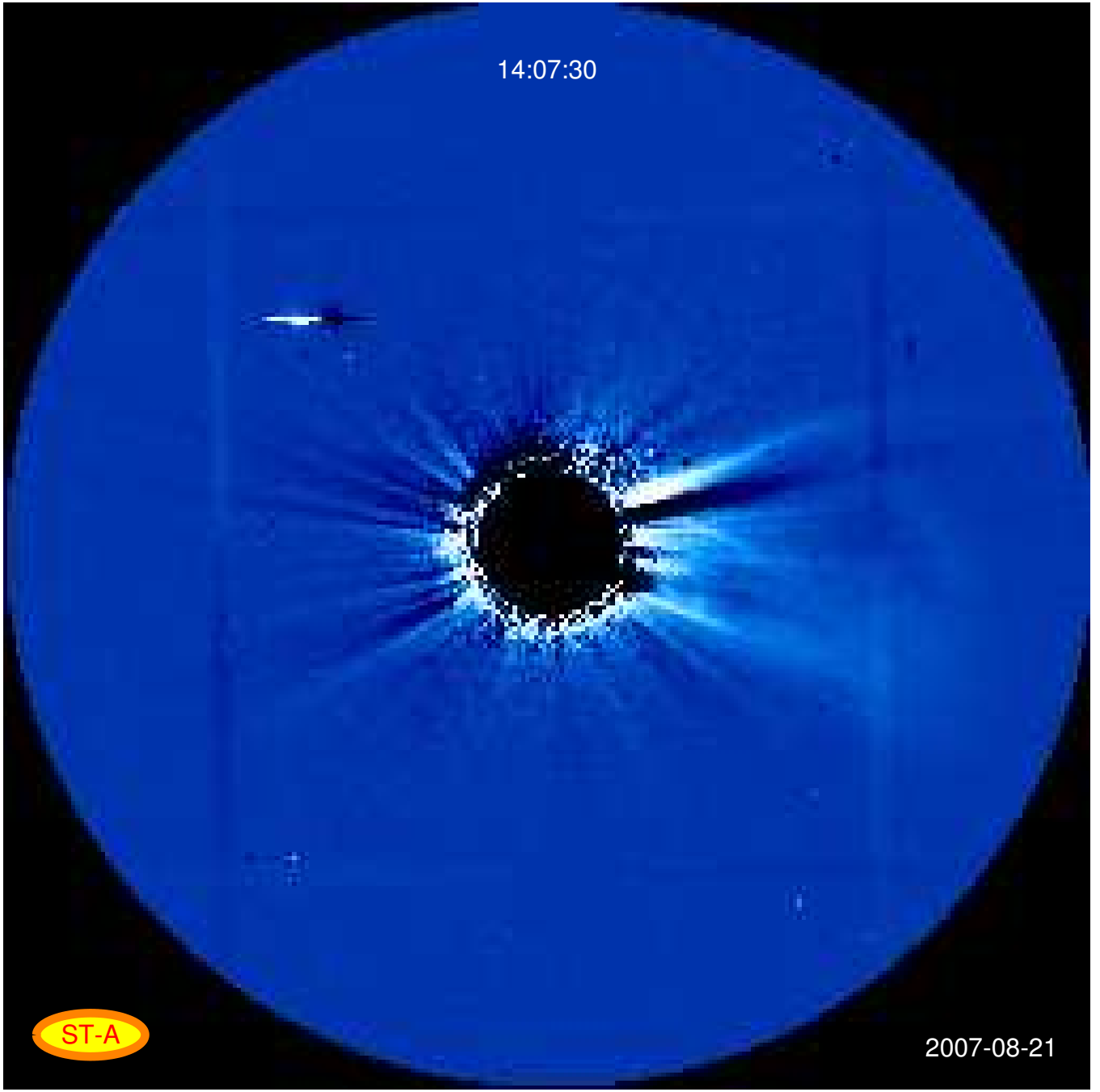

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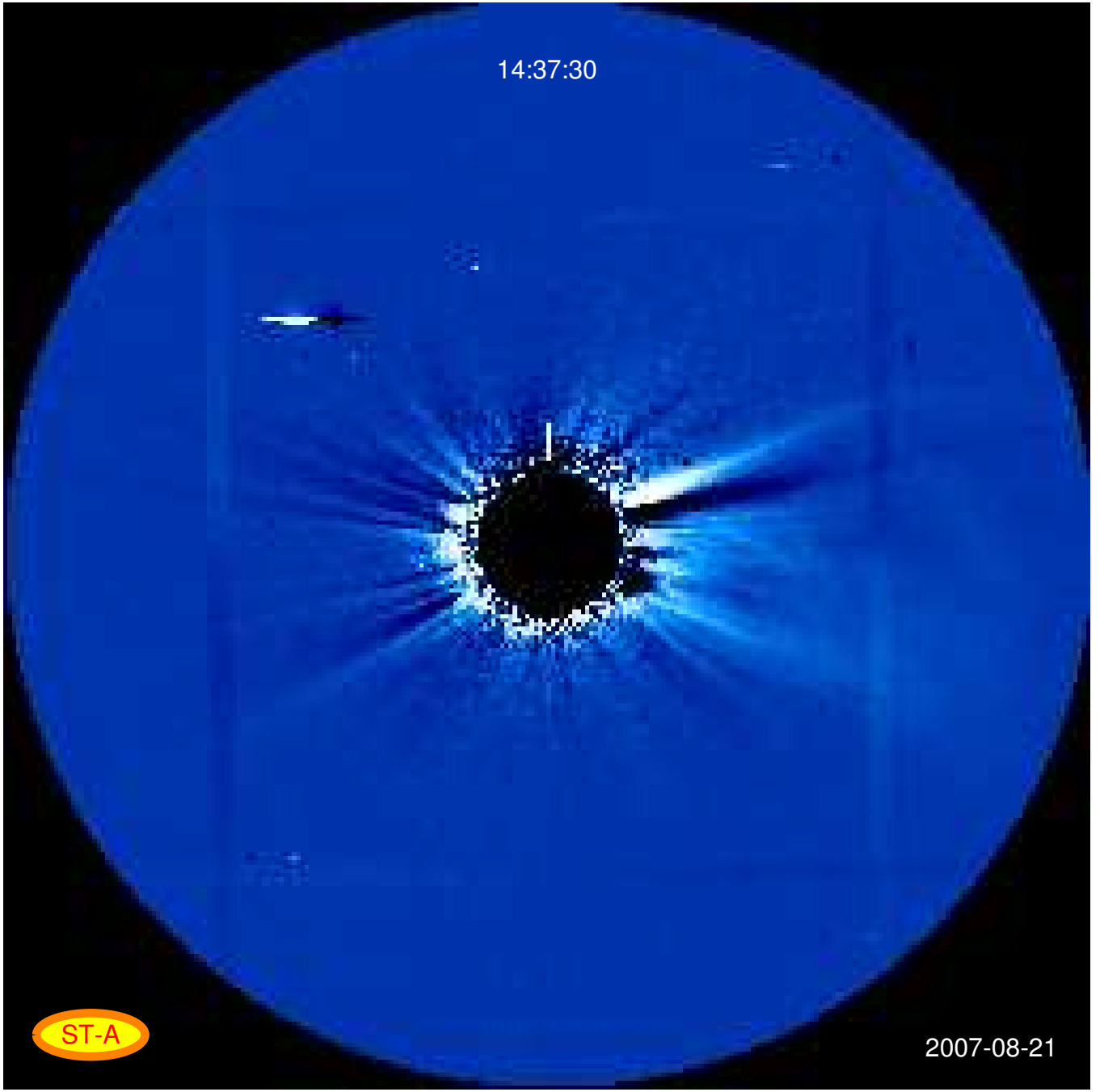

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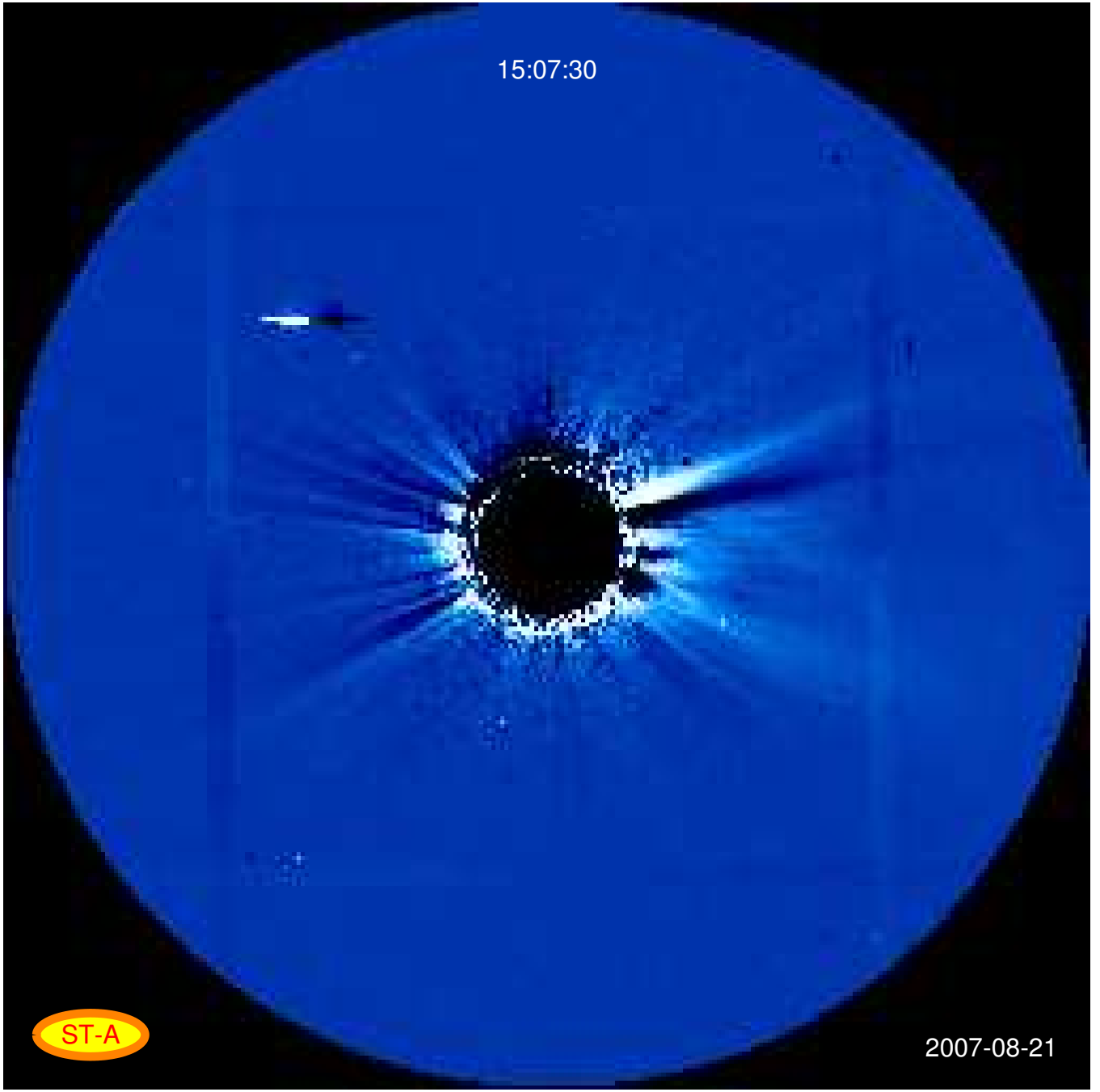

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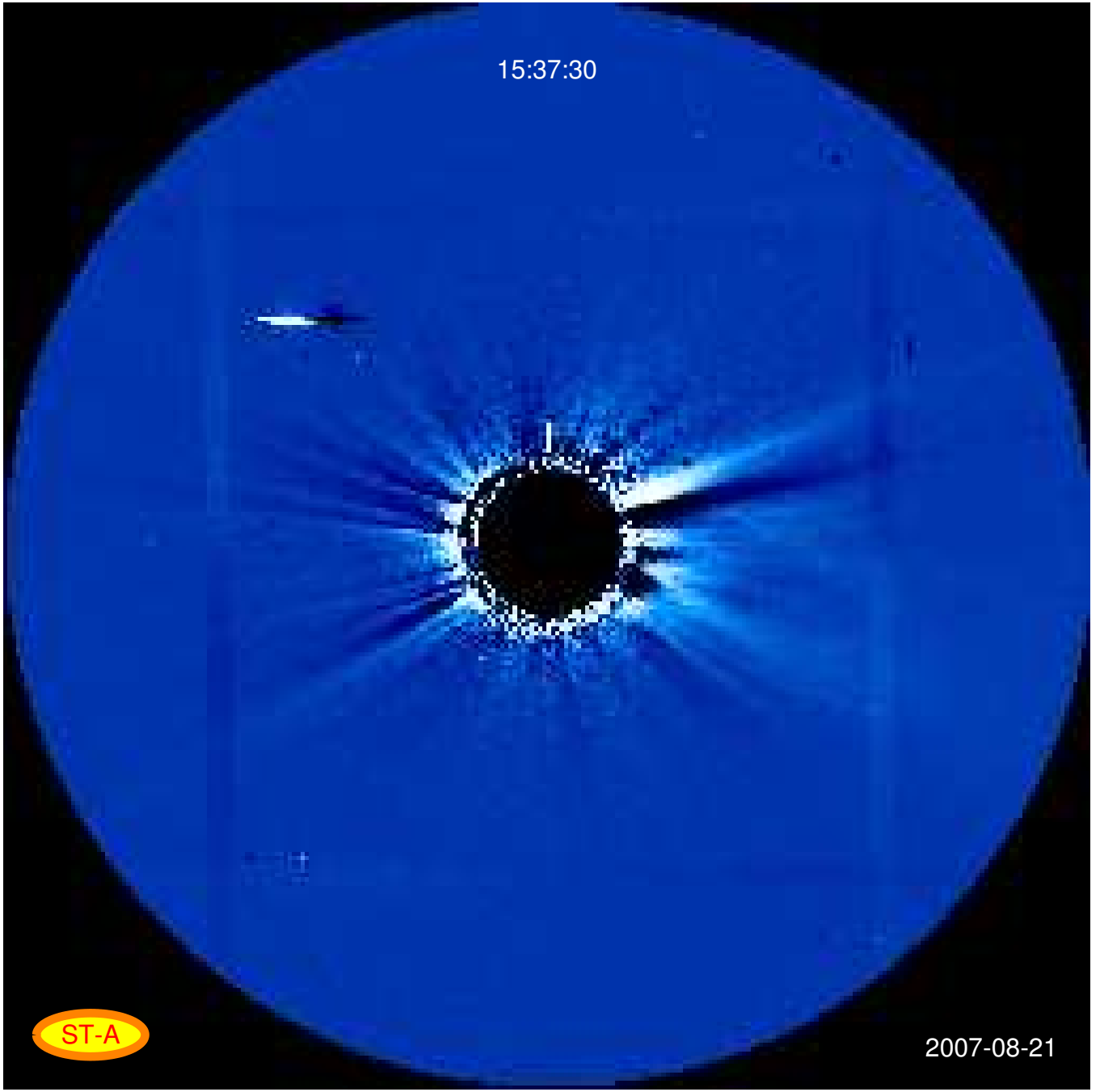

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To replay movie, poke Opus in the eye

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Spacecraft	First CME Image	Last CME Image
STEREO-A	0707	1537
STEREO-B	1008†	1538

† Initial CME identification at STEREO-B significantly later than at STEREO-A because of "feature" /defect in STEREO-B coronagraph

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Geometric Localization

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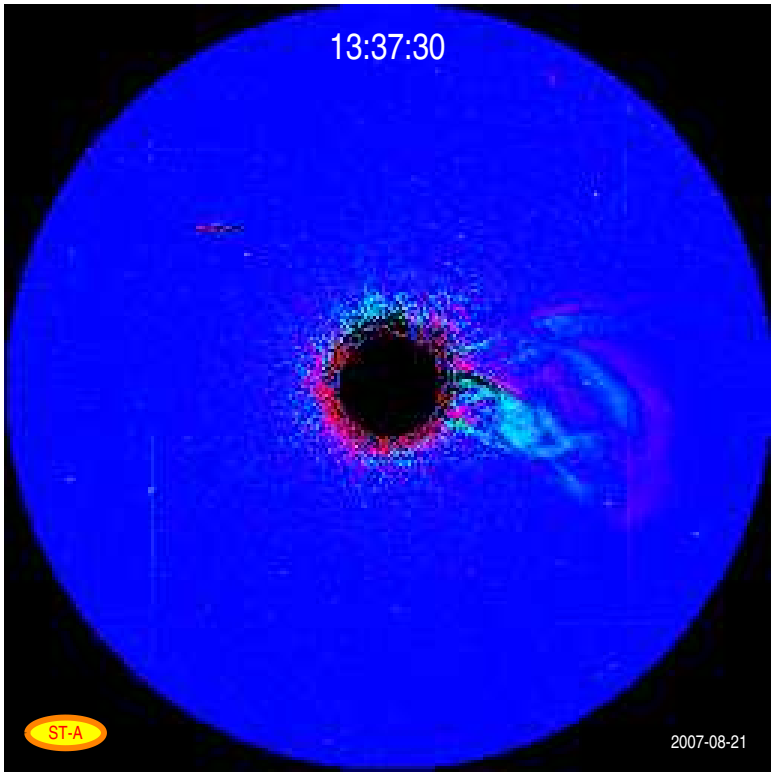
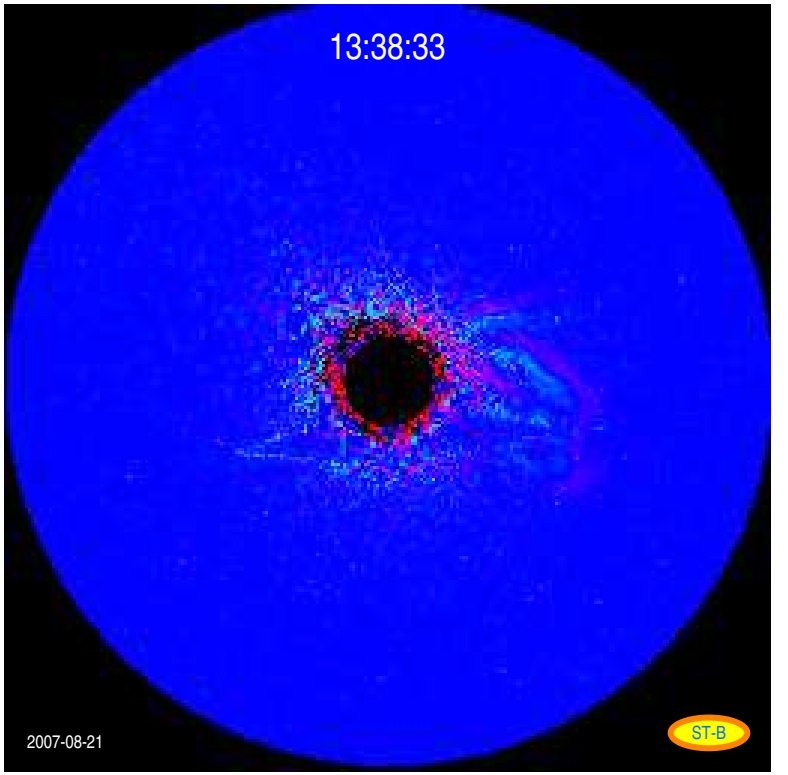
Example





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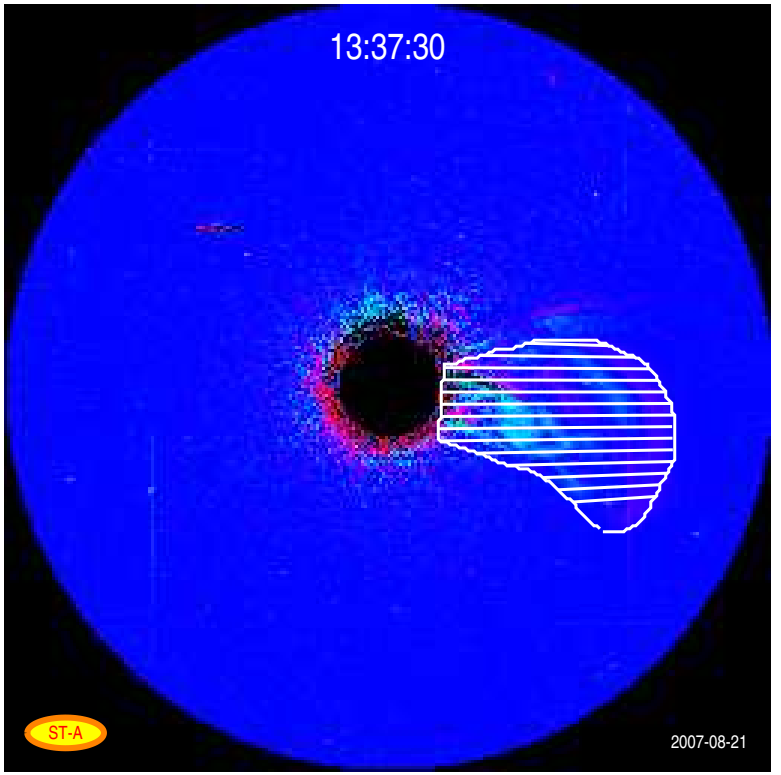

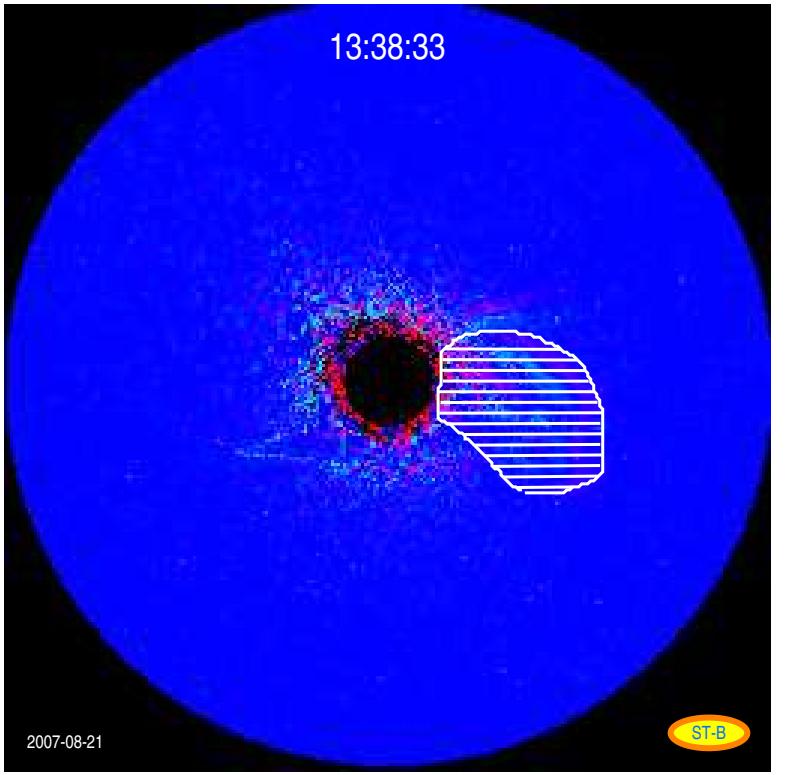

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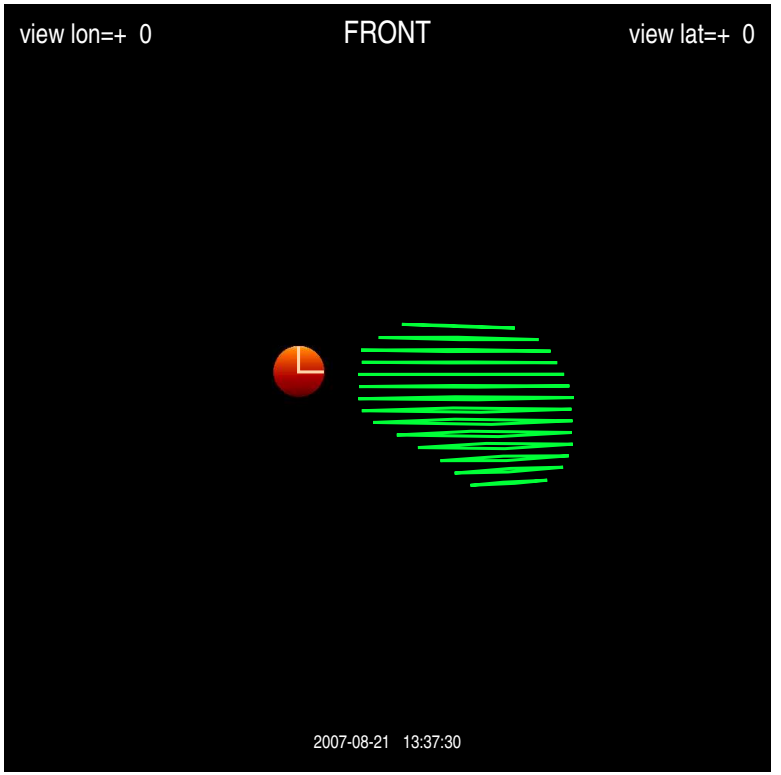

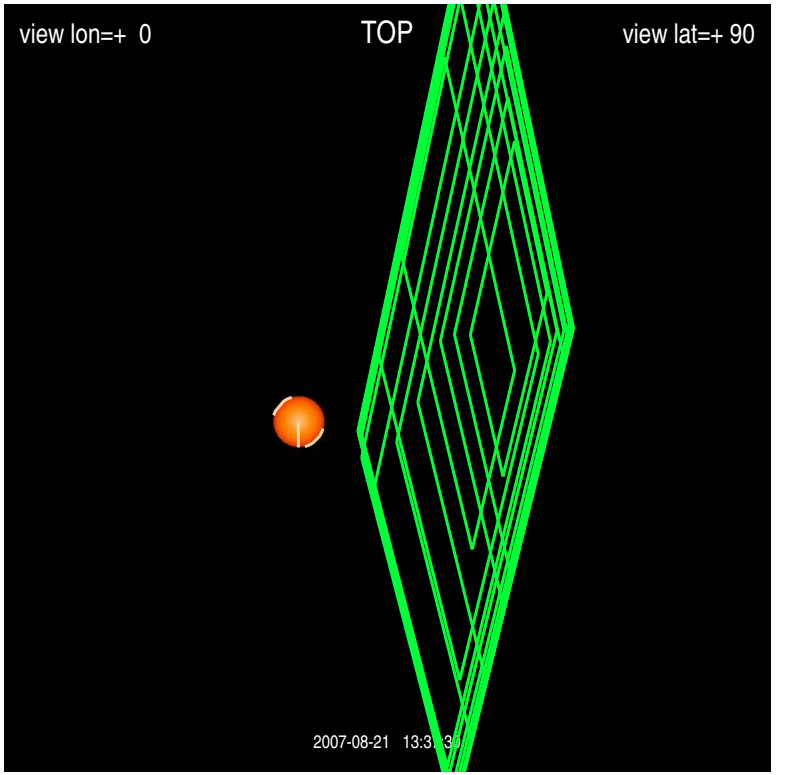

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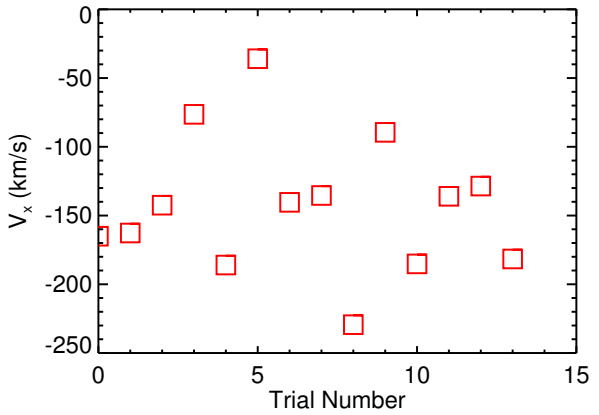

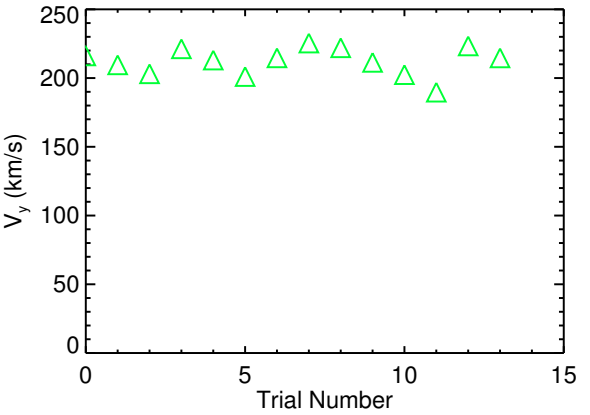

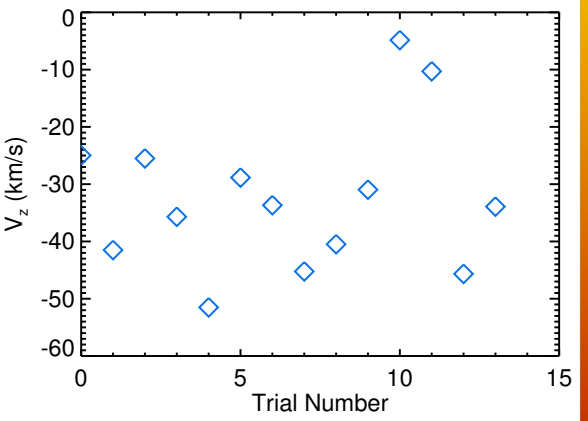

Resultant velocity of 21 August 2007 CME

CME speed $257 \pm 29\,\mathrm{km \cdot s^{-1}}$.

CME latitude $7^\circ \pm 3^\circ$ S

CME longitude $124^\circ \pm 9^\circ$ W

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Possible Source

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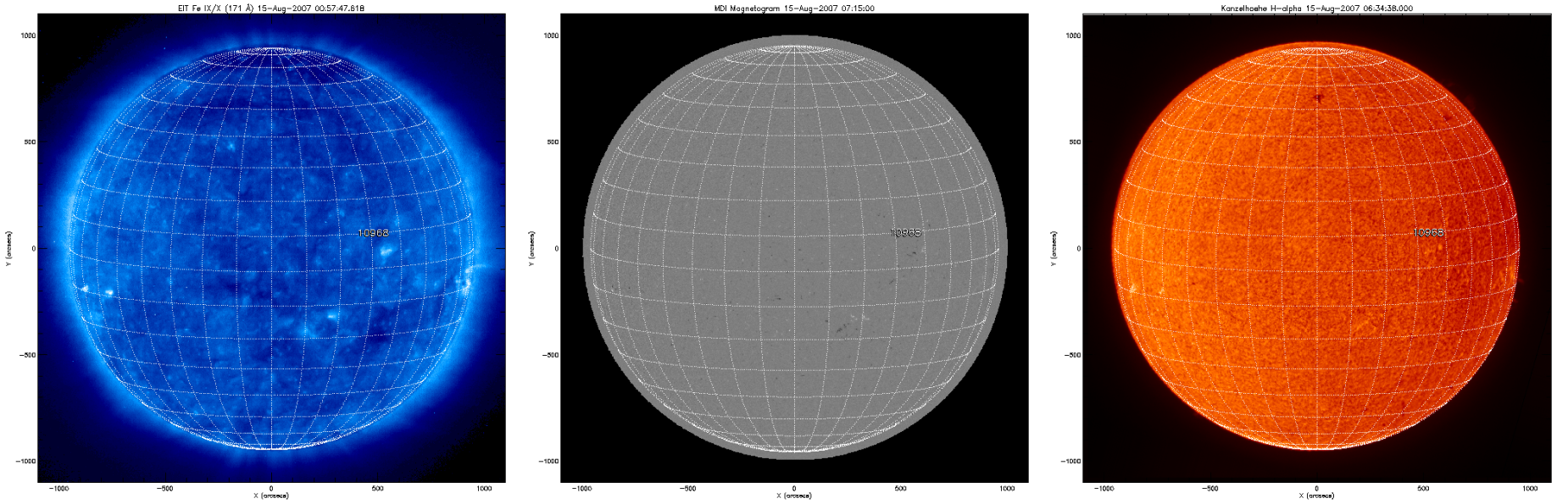

Possible source observed on 15 August 2007

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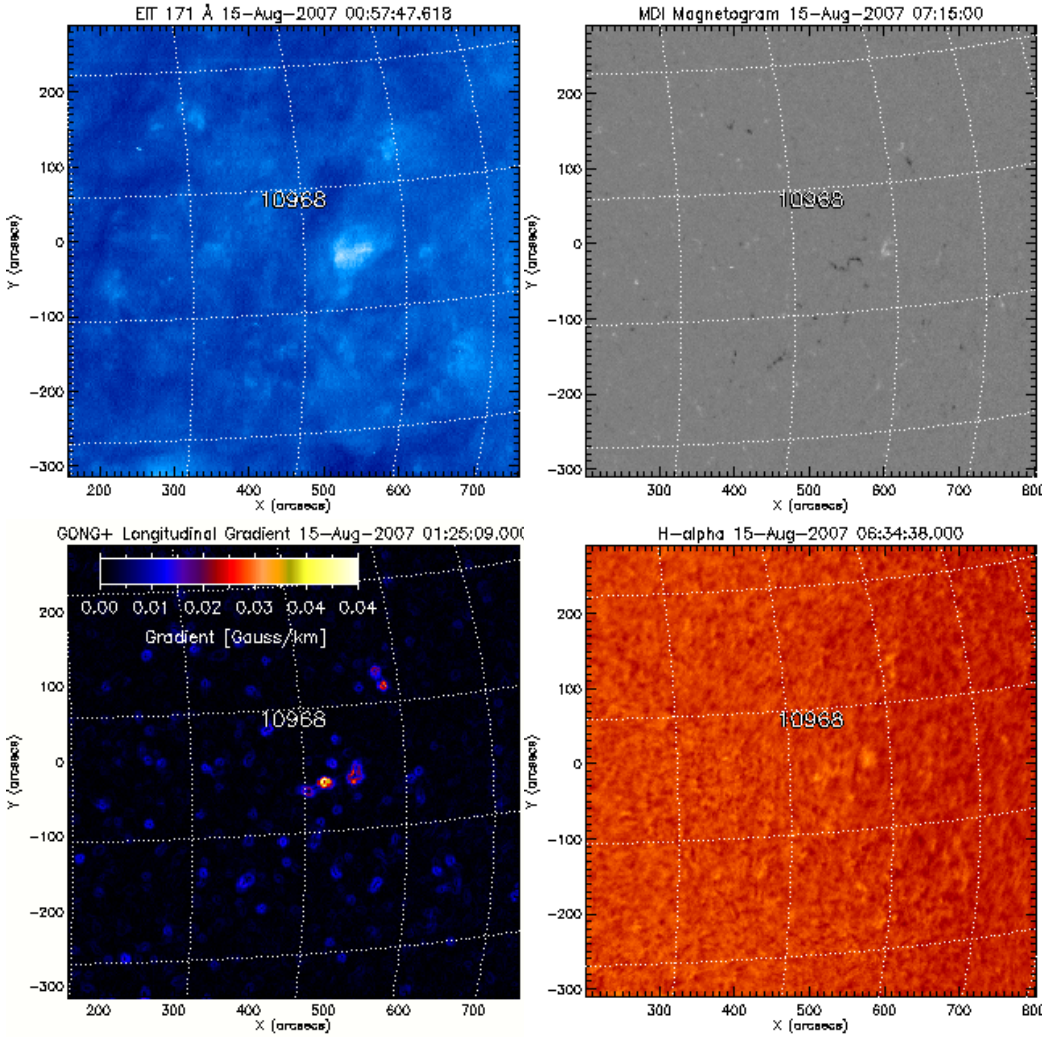

NOAA AR 10968

- observed for only 2 days
- small region
- 3 sunspots first day
- 4 sunspots second day

Observed Location

14 Aug: (N03, W33)

15 Aug: (N05, W37)

Projected Location

21 Aug: (N05, W116)

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Alternatively . . .

- active region responsible for CME may have formed on far side of Sun
- projected appearance of far-side active region on eastern limb is 31 Aug–2 Sep

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Alternatively . . .

- active region responsible for CME may have formed on far side of Sun
- projected appearance of far-side active region on eastern limb is 31 Aug–2 Sep

However, nothing was observed in the days following 31 Aug

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Additional Activity

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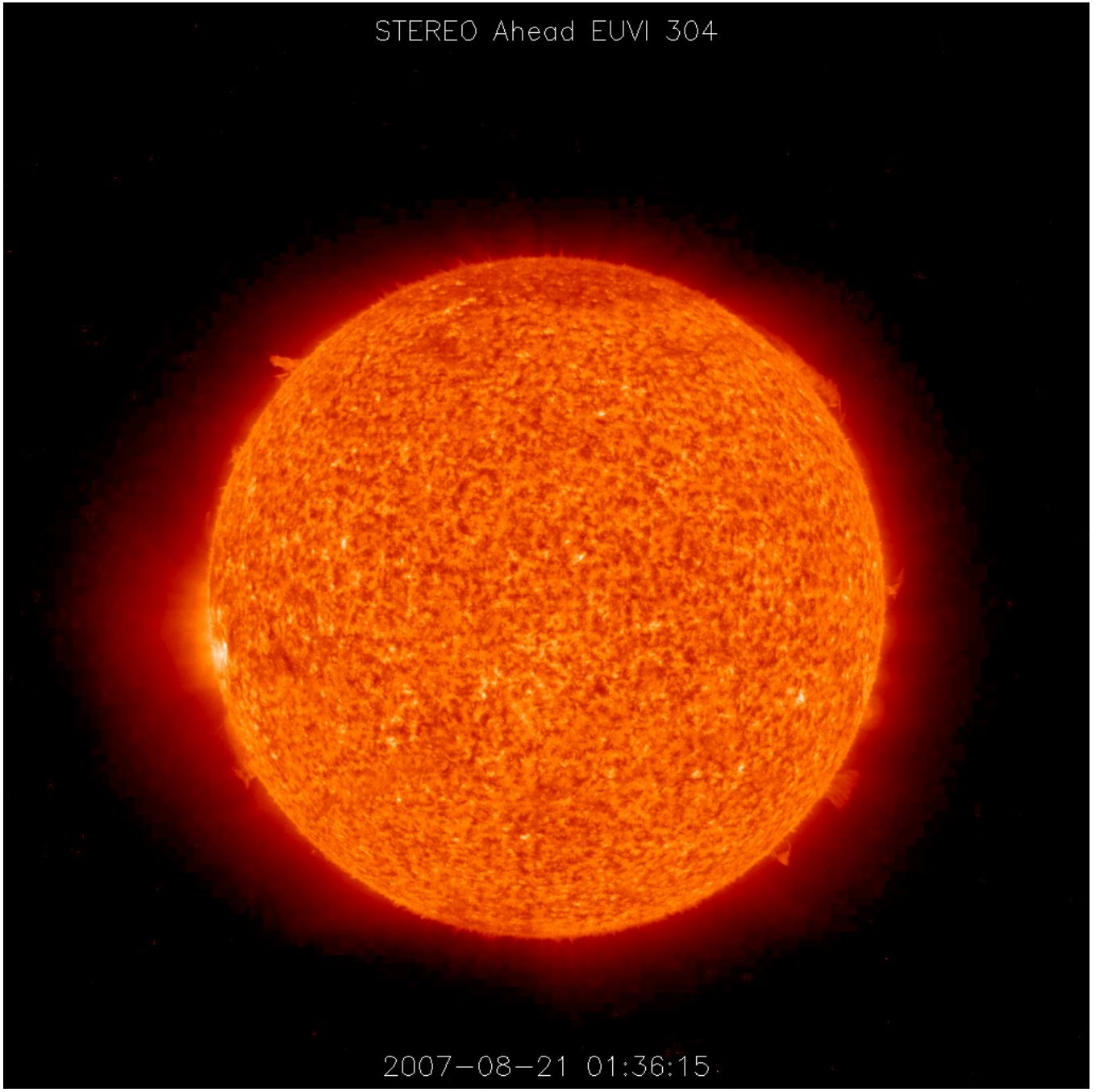

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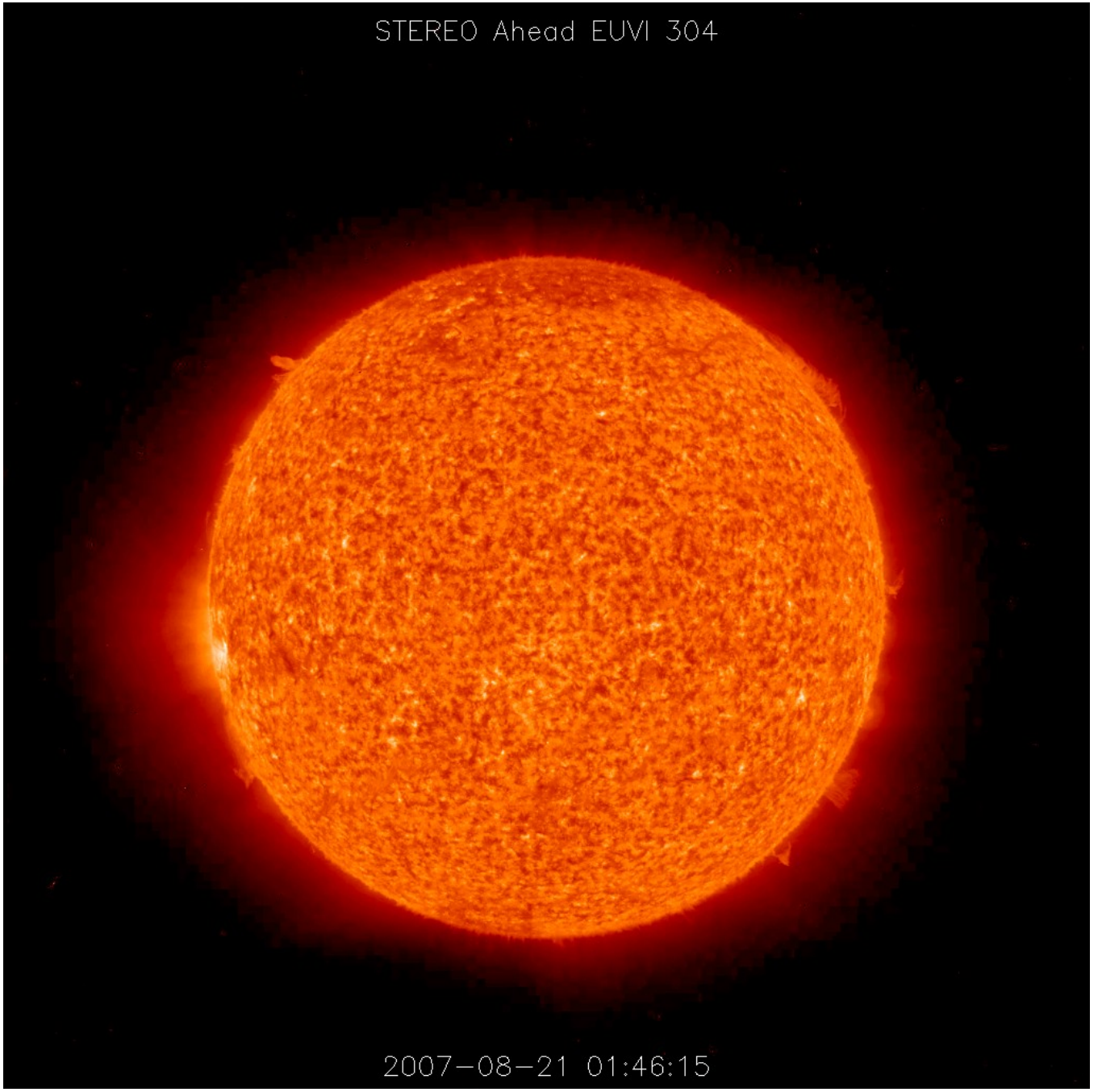

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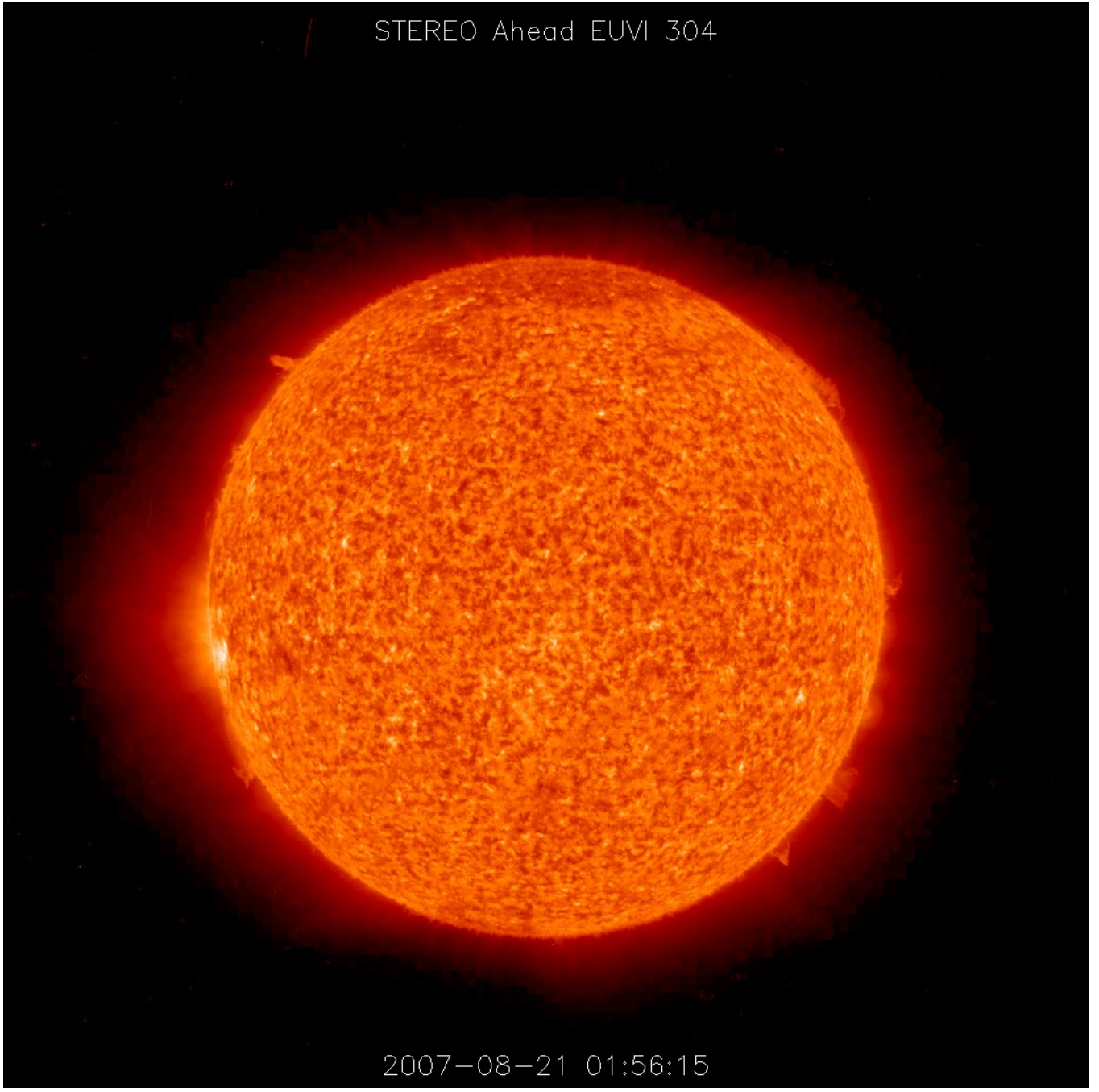

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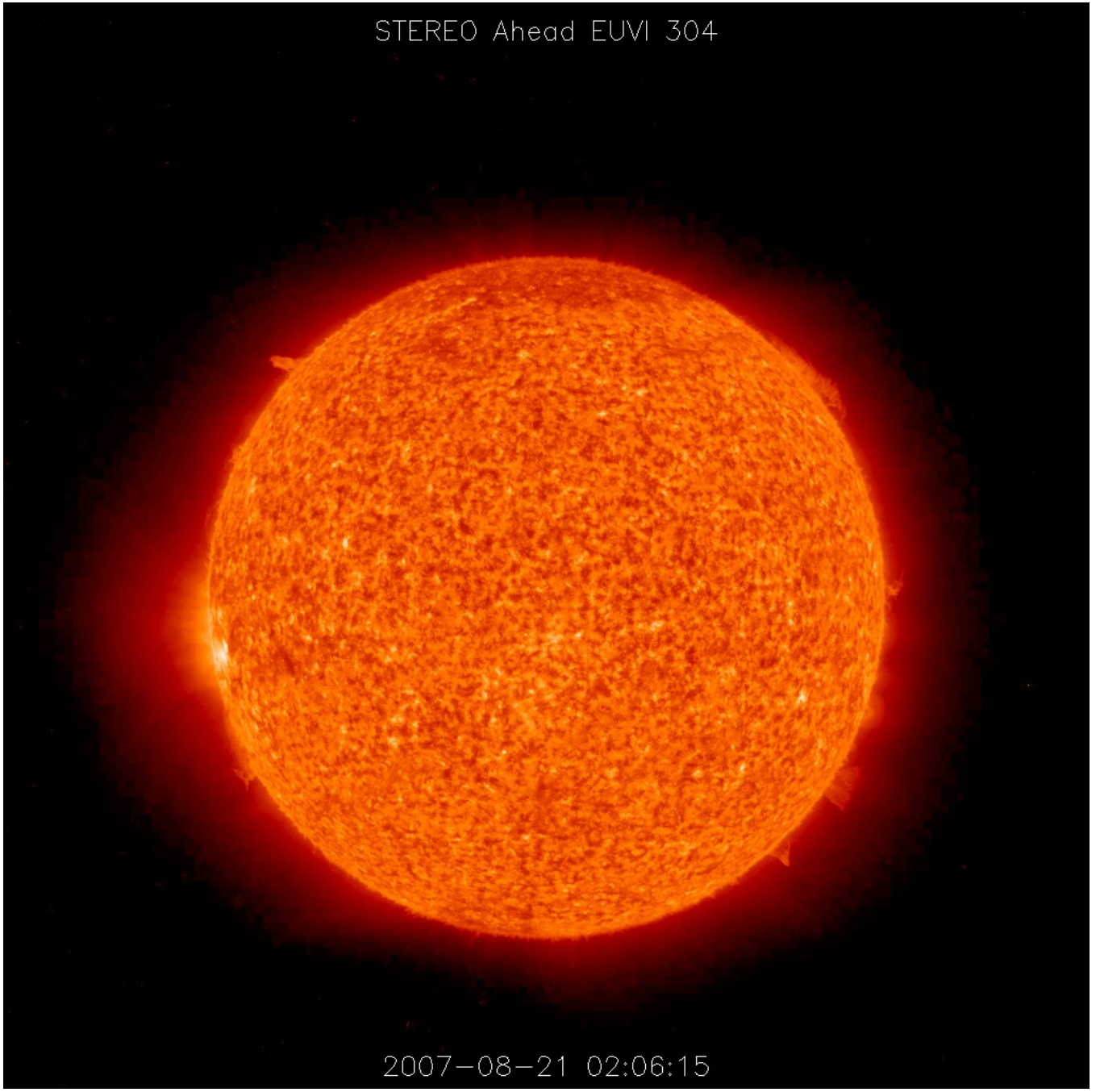

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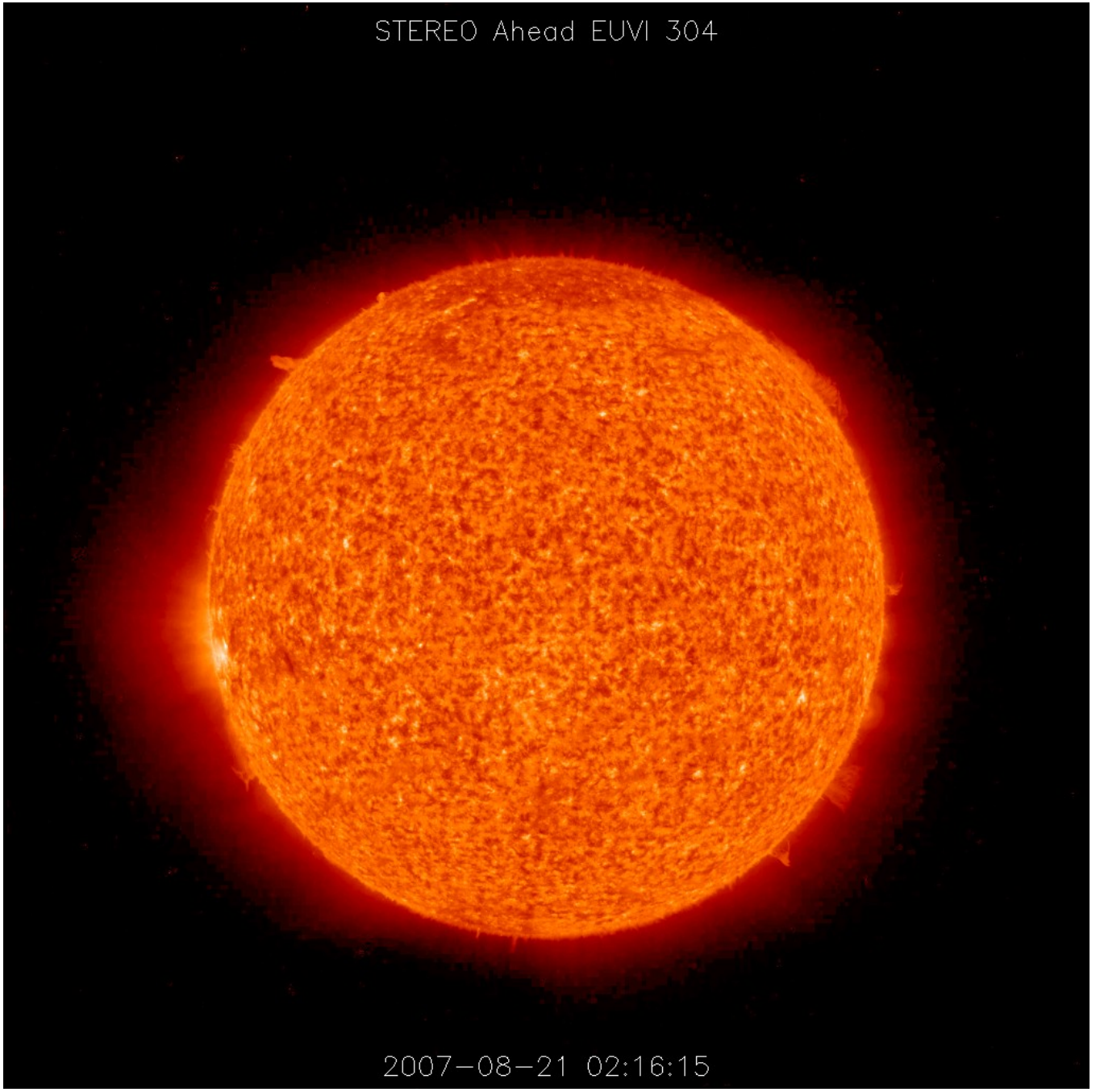

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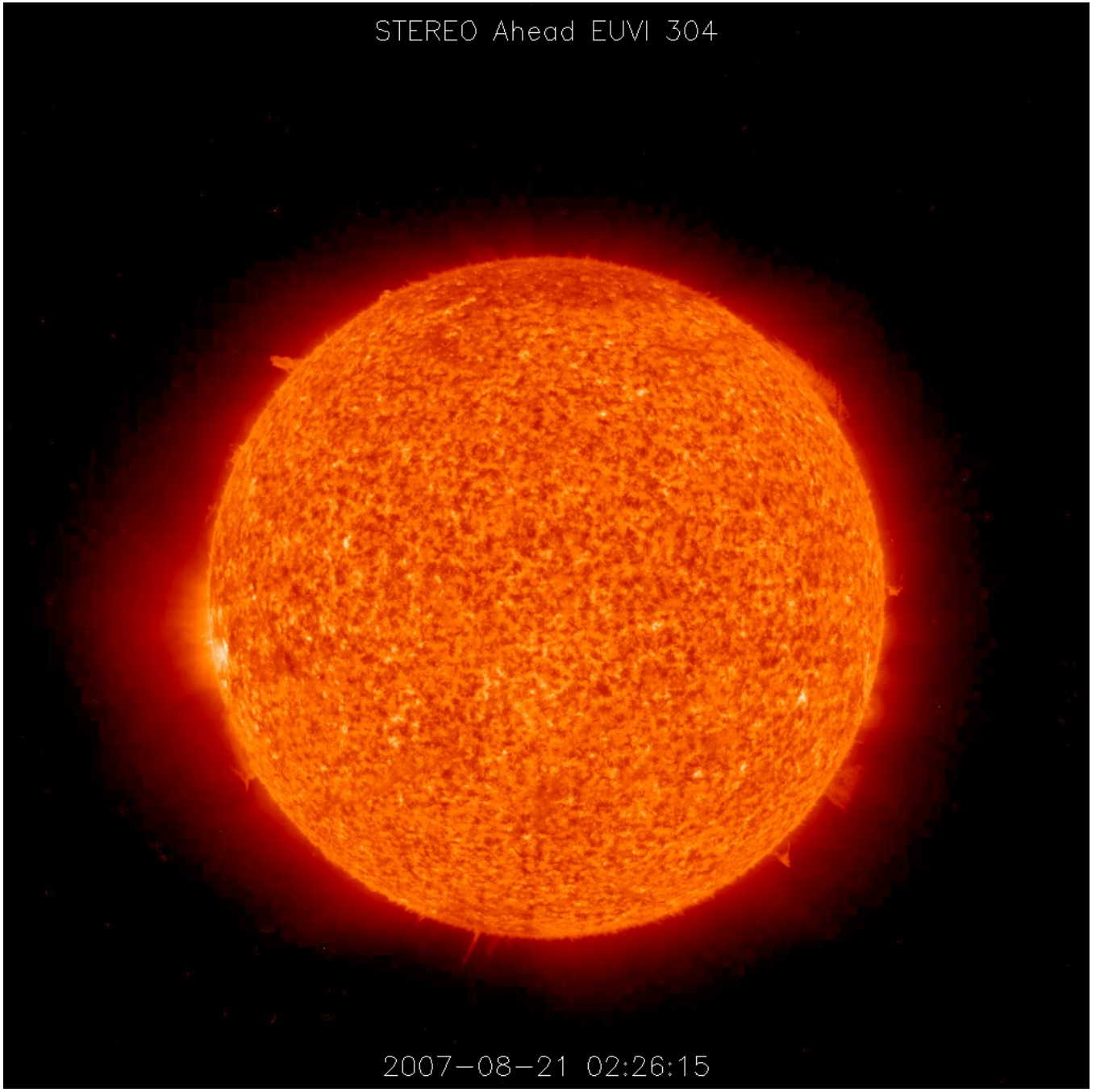

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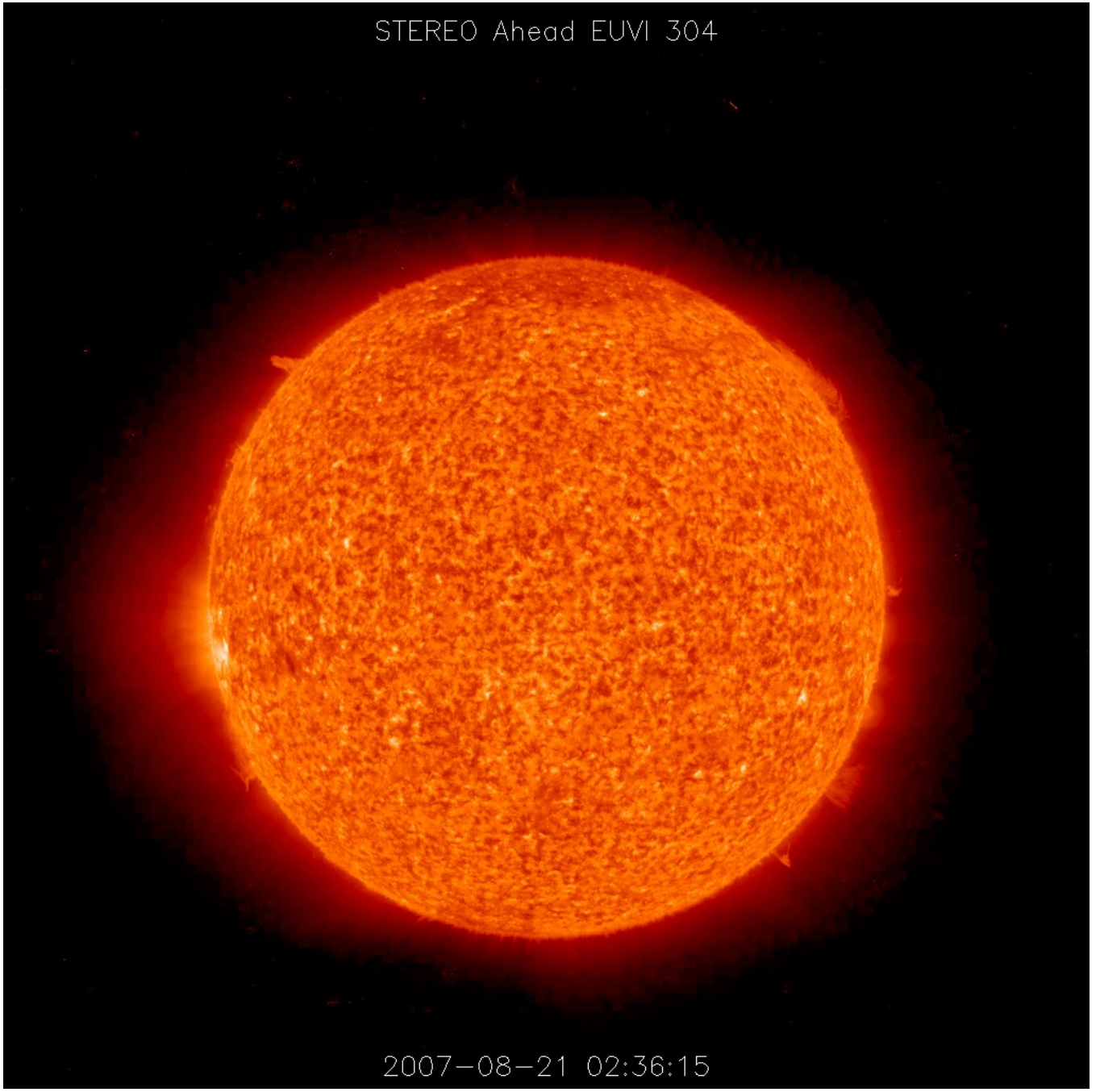

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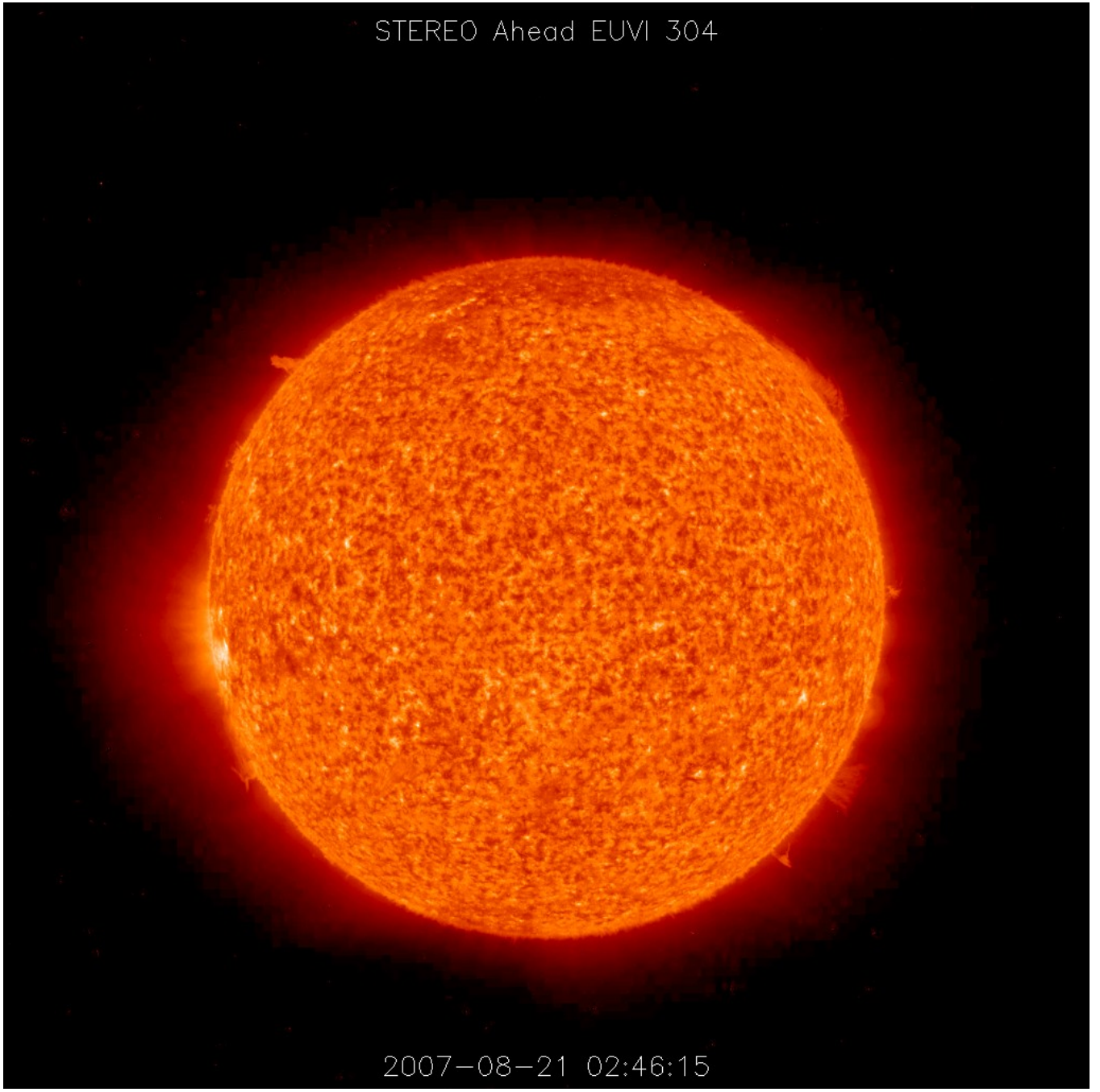

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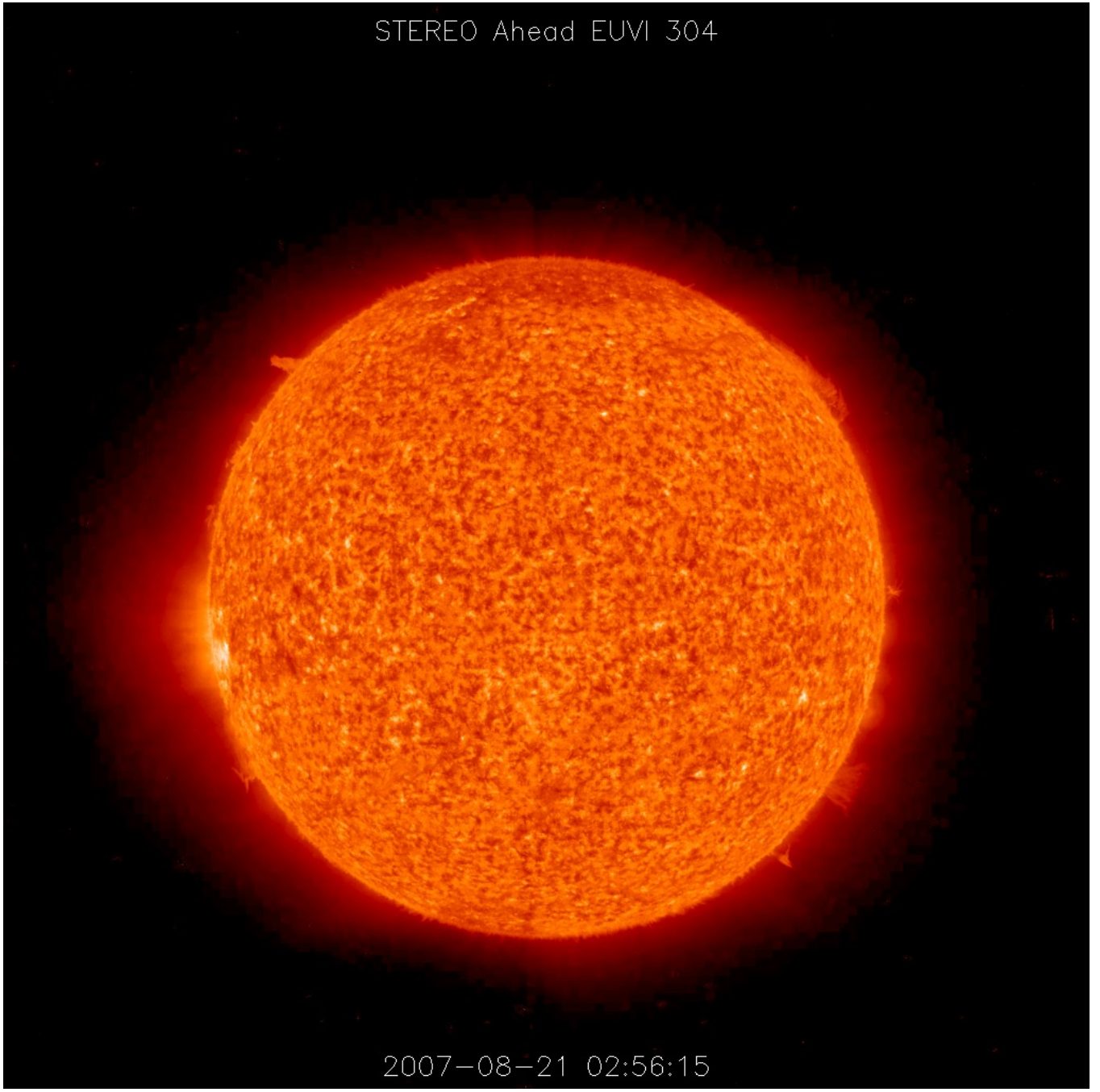

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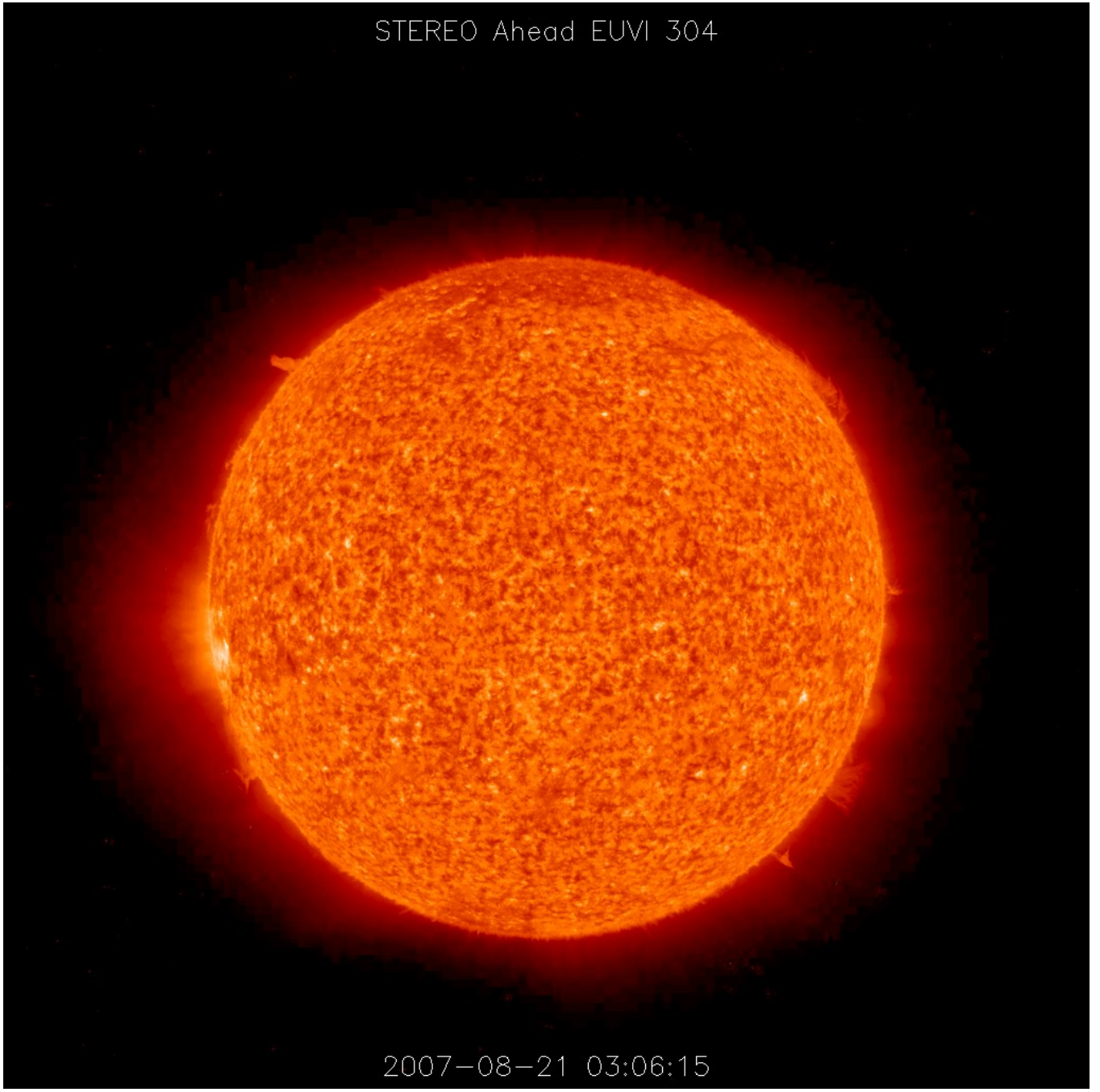

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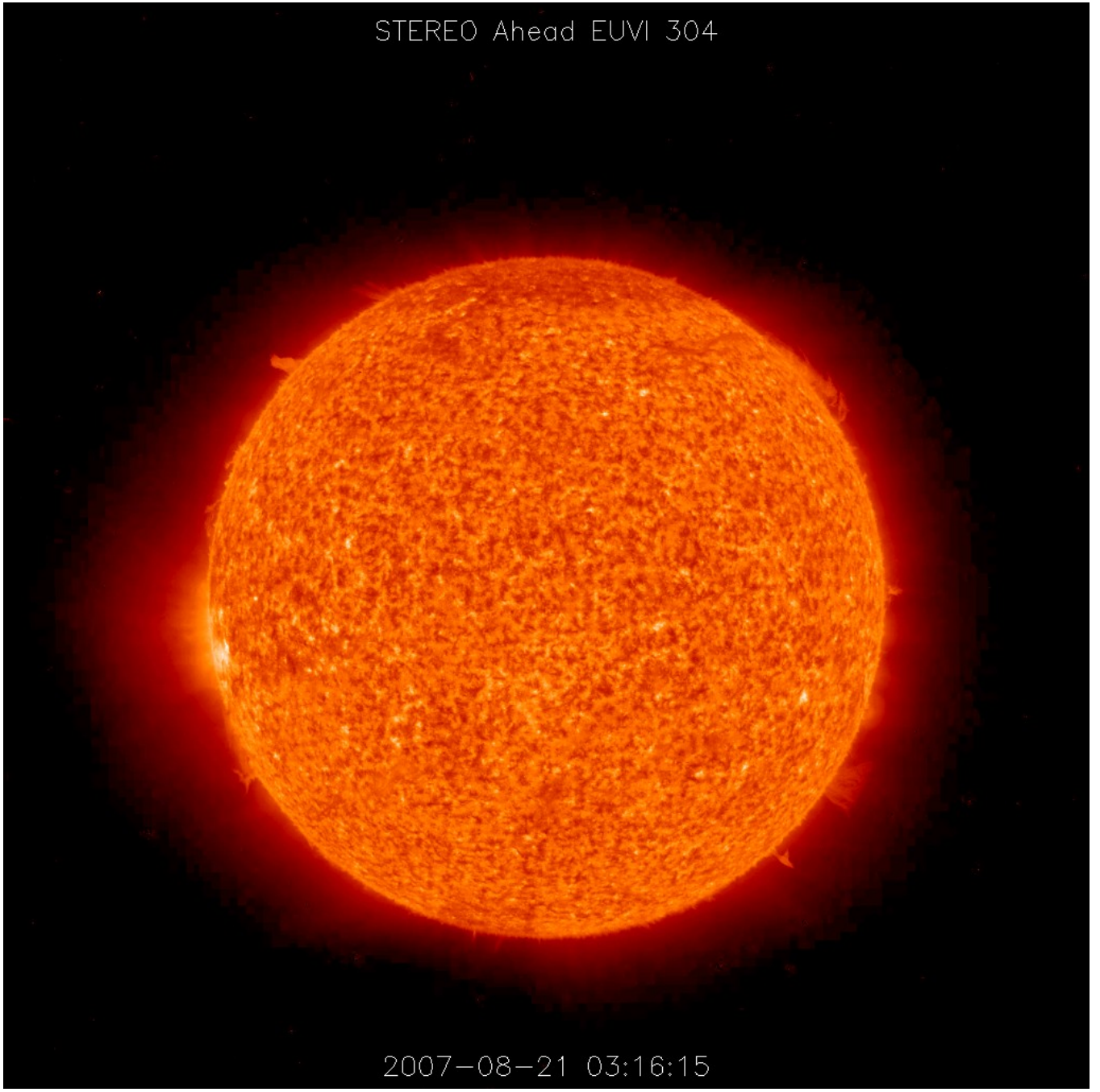

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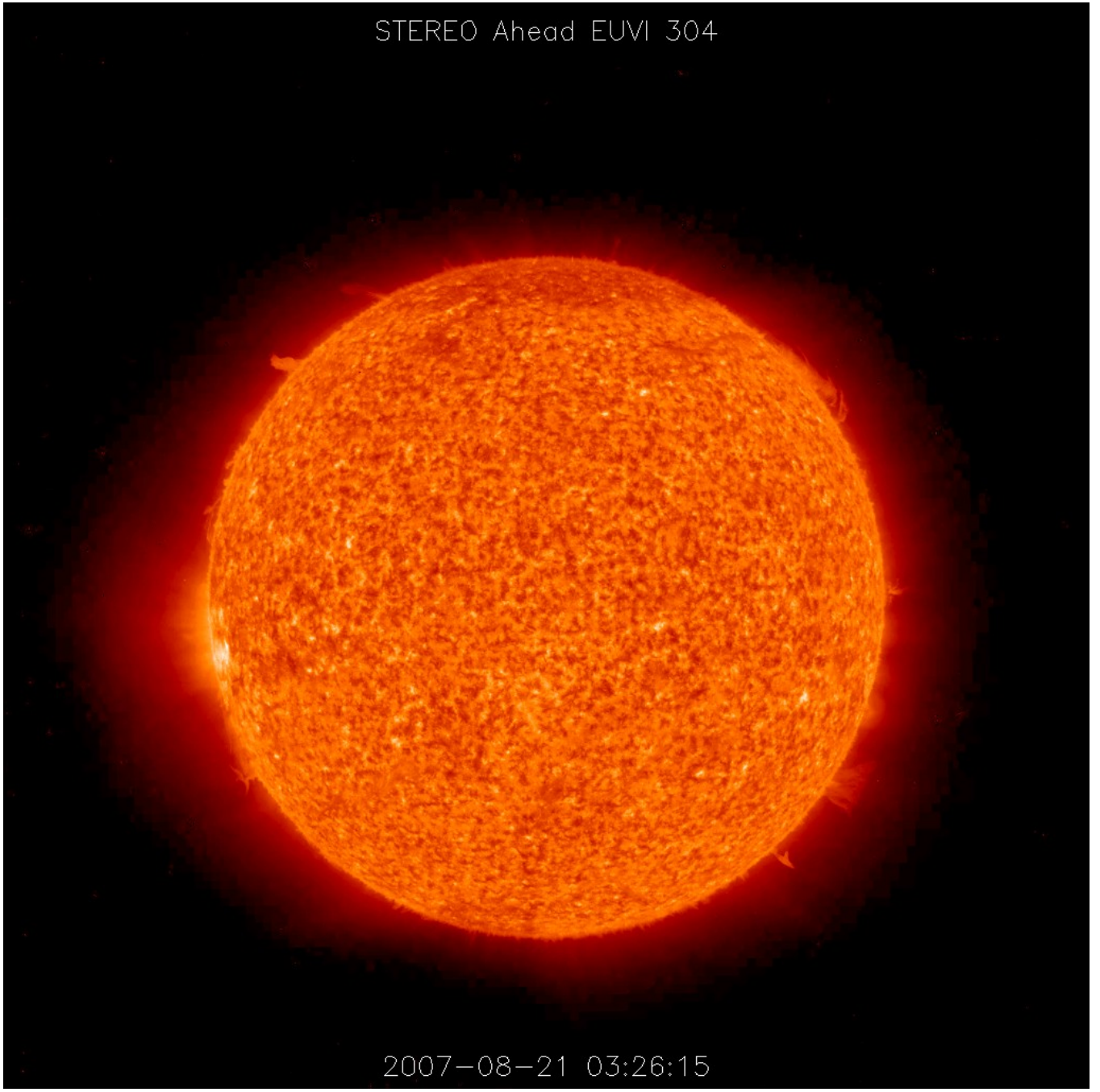

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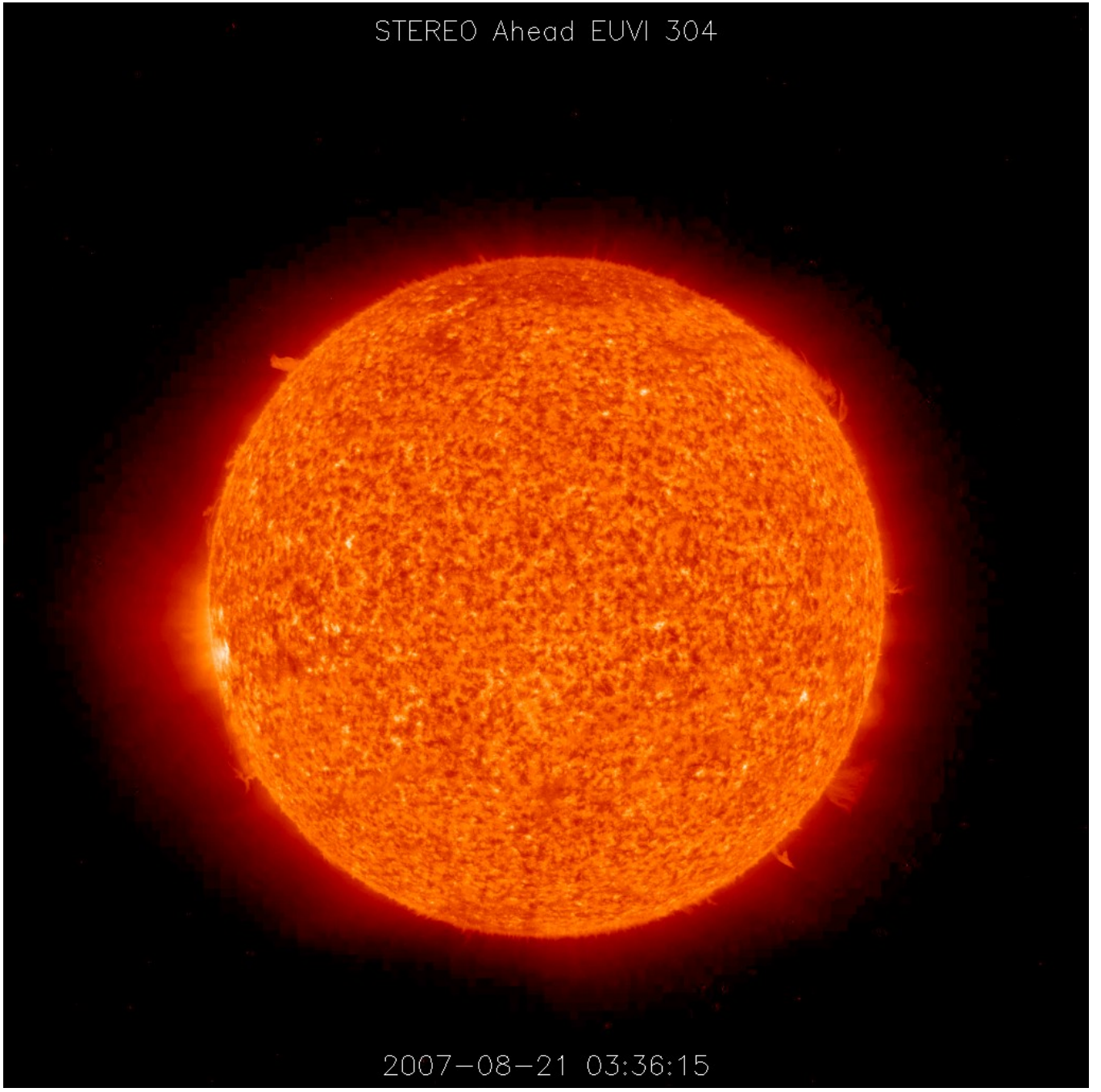

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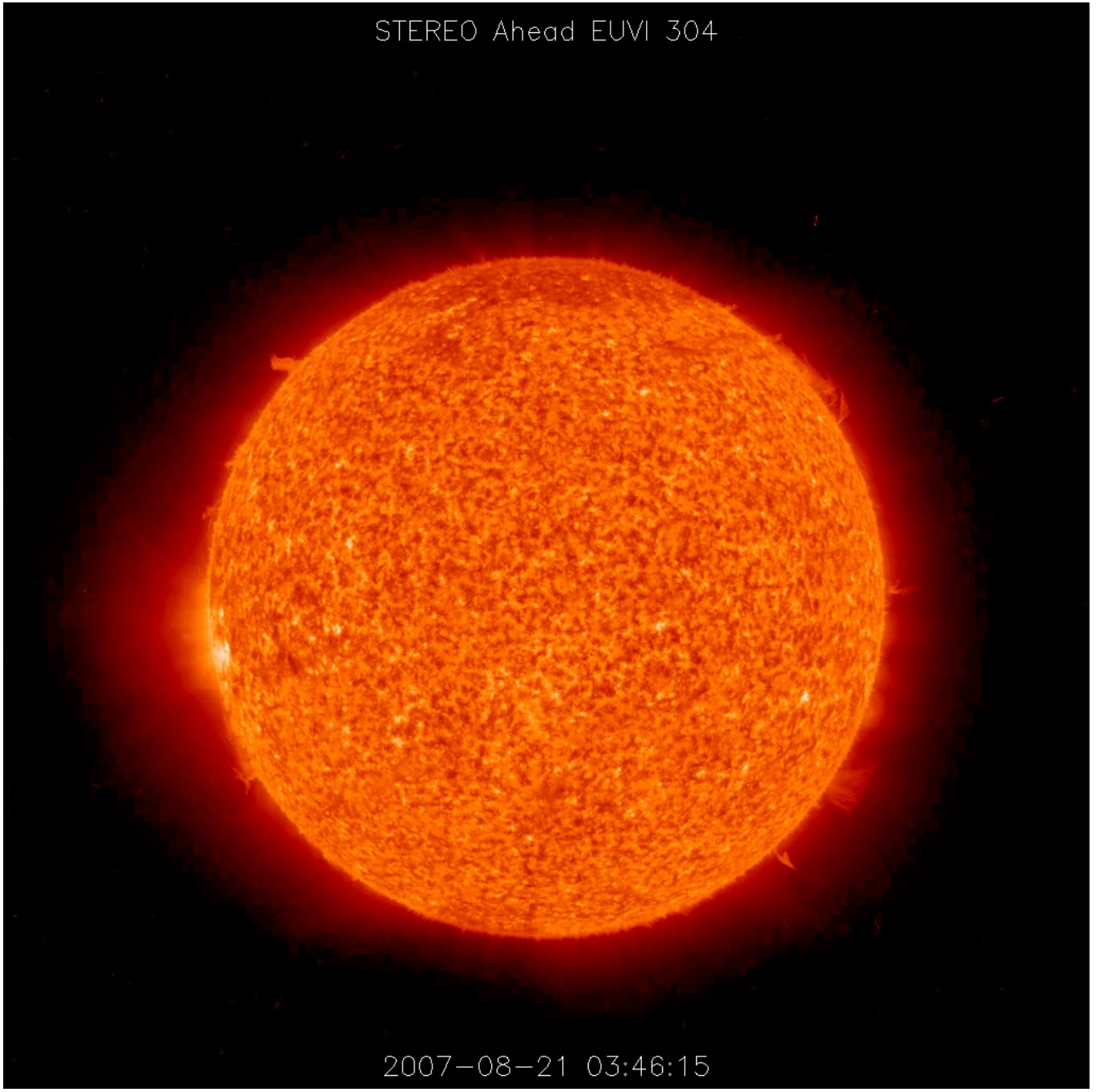

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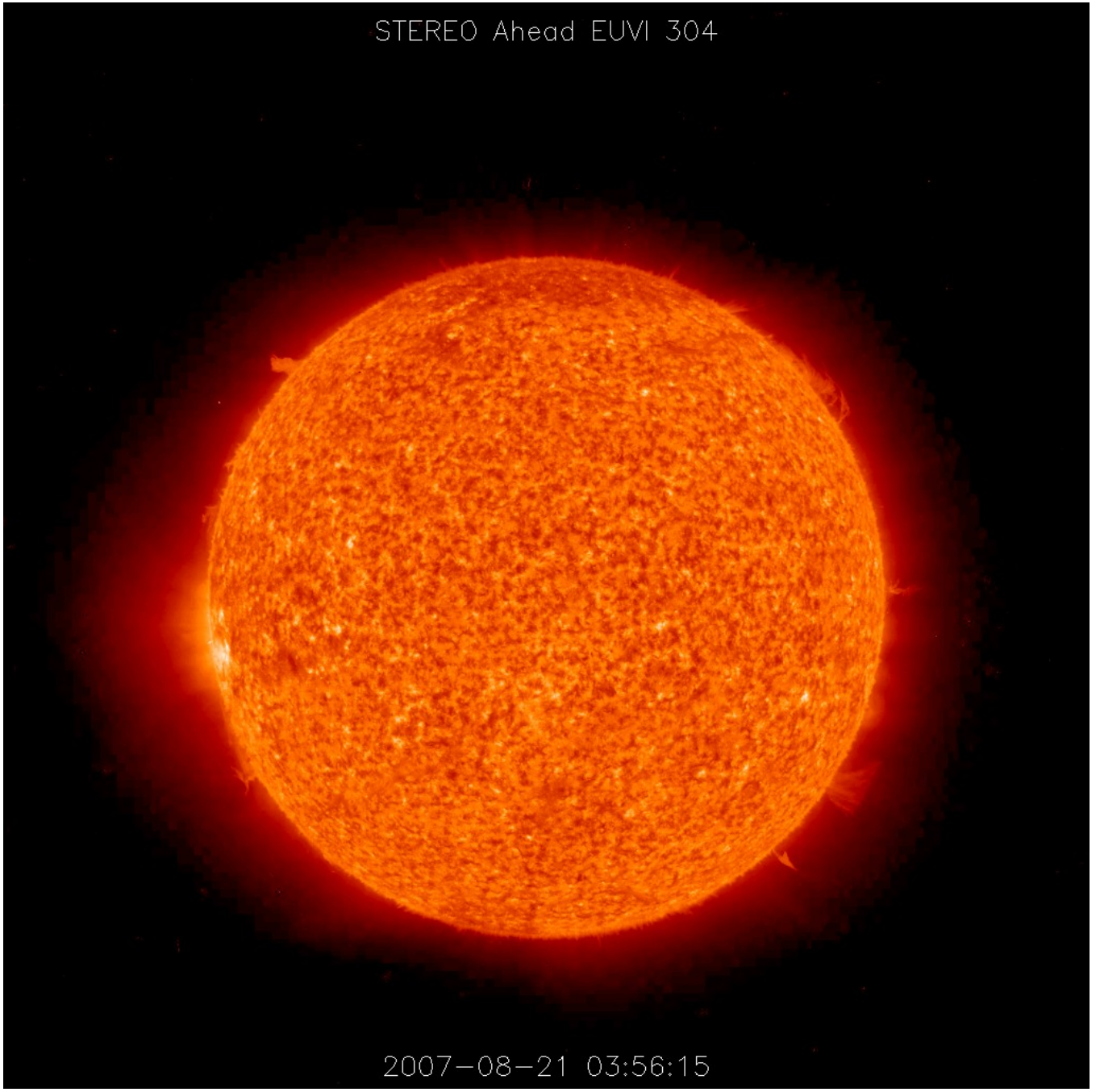

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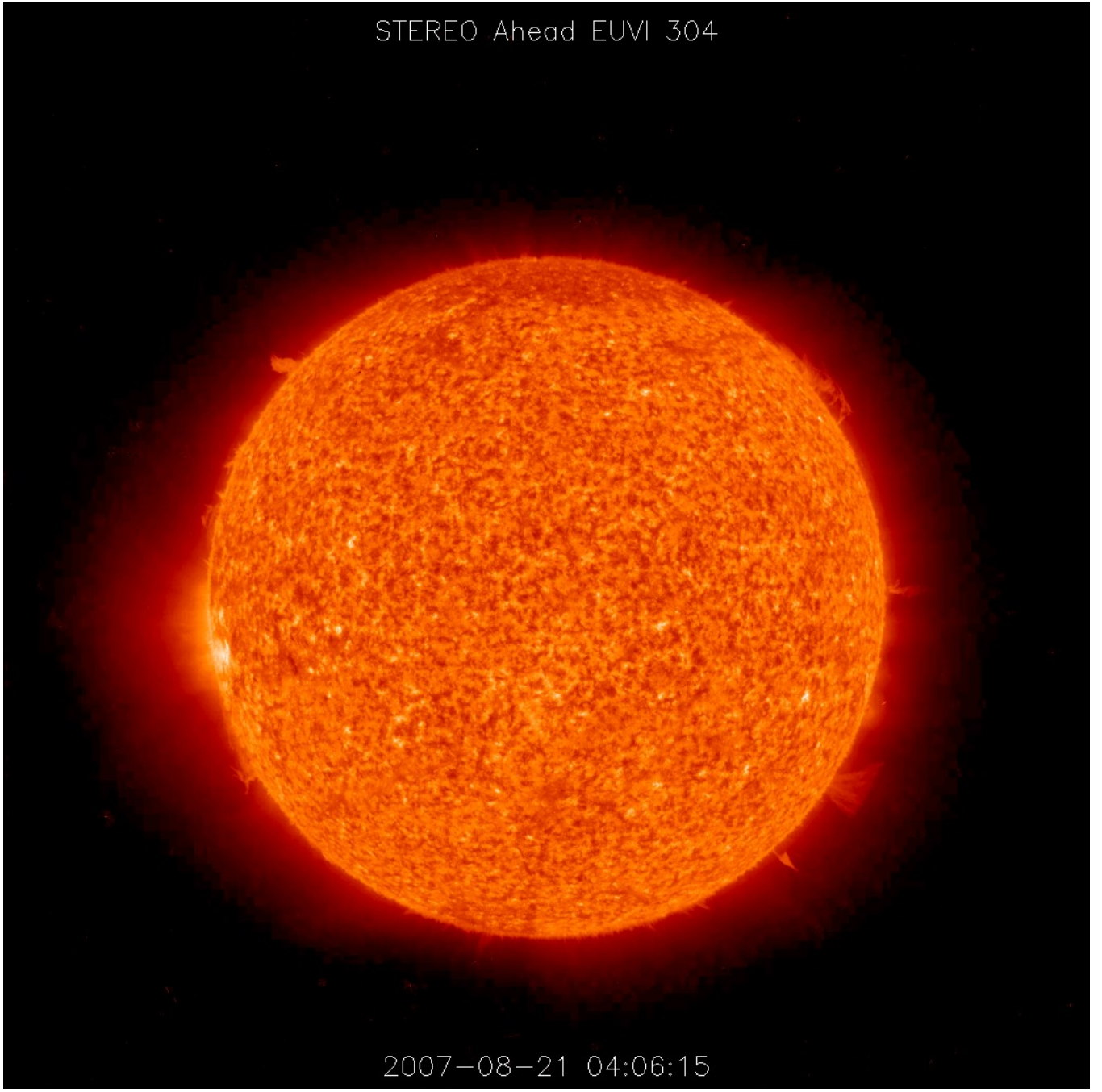

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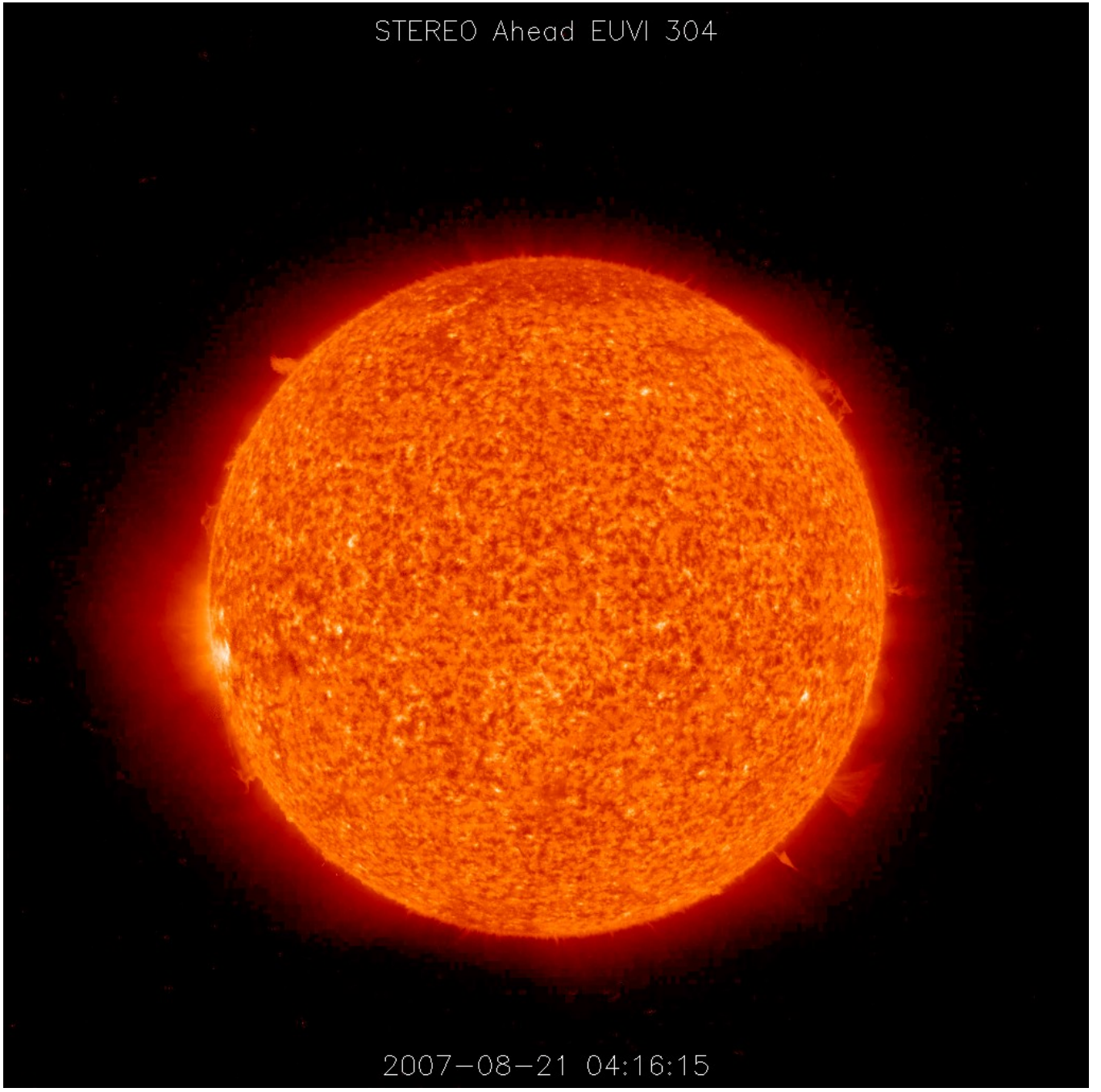

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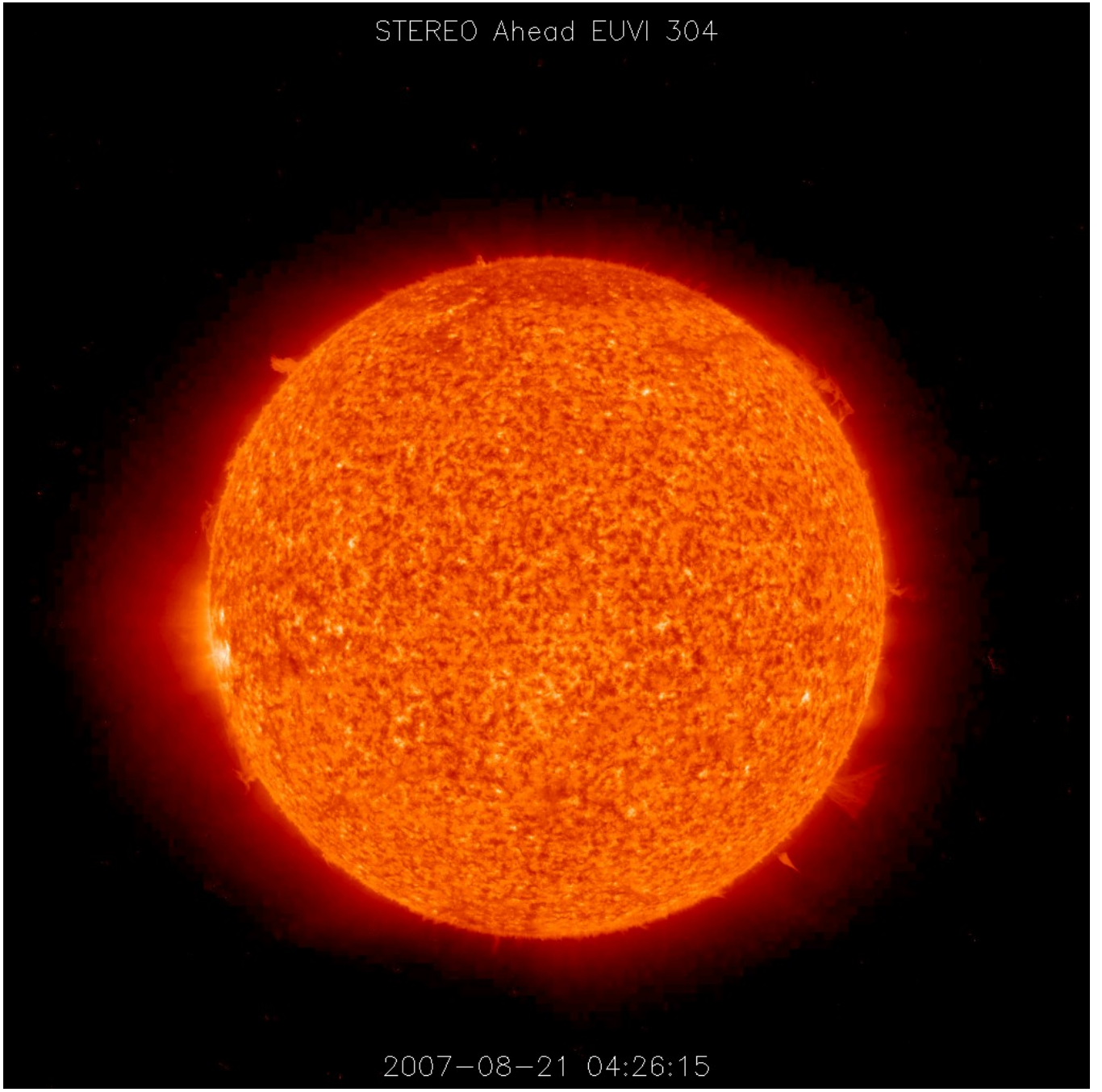

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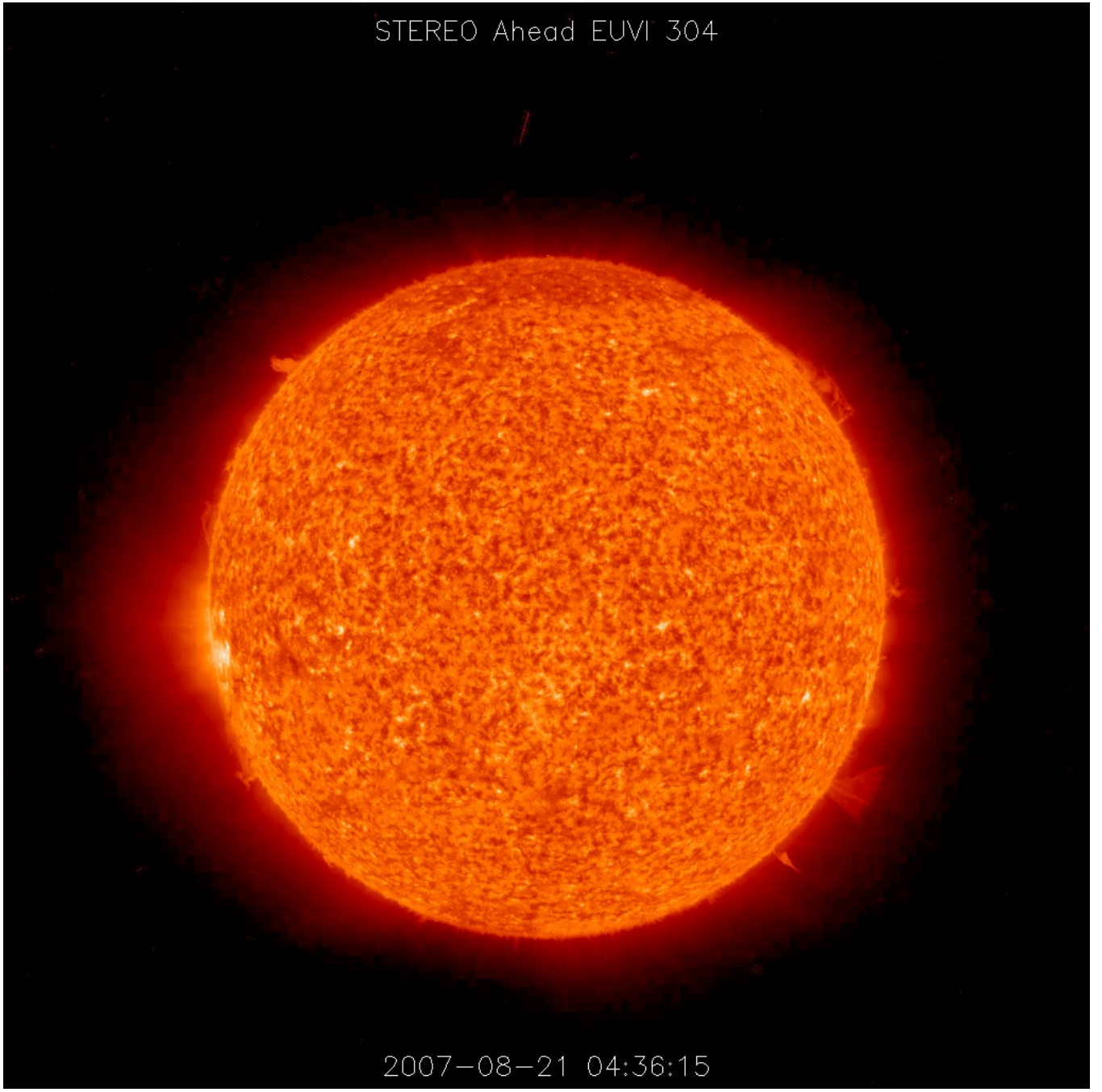

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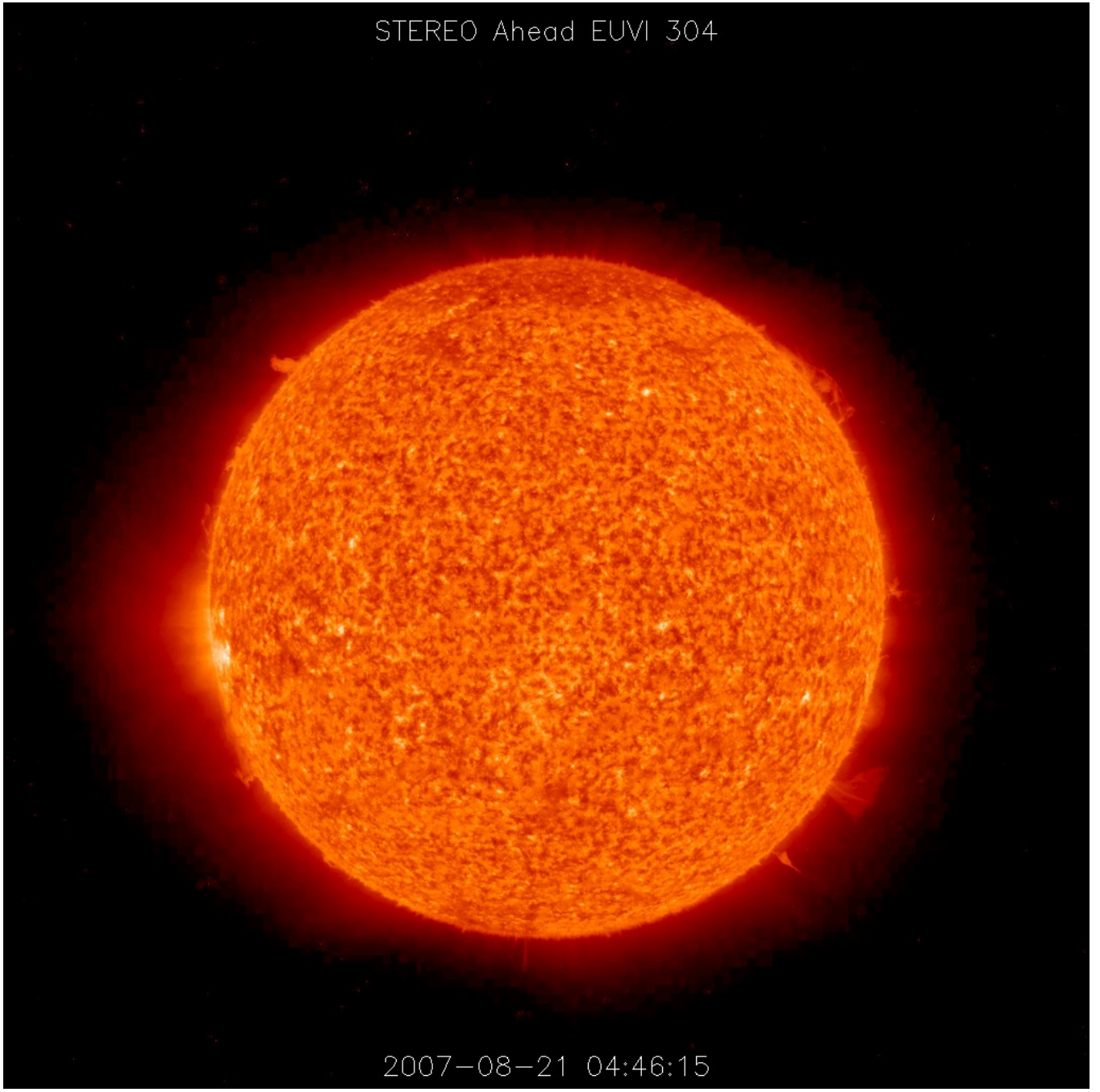

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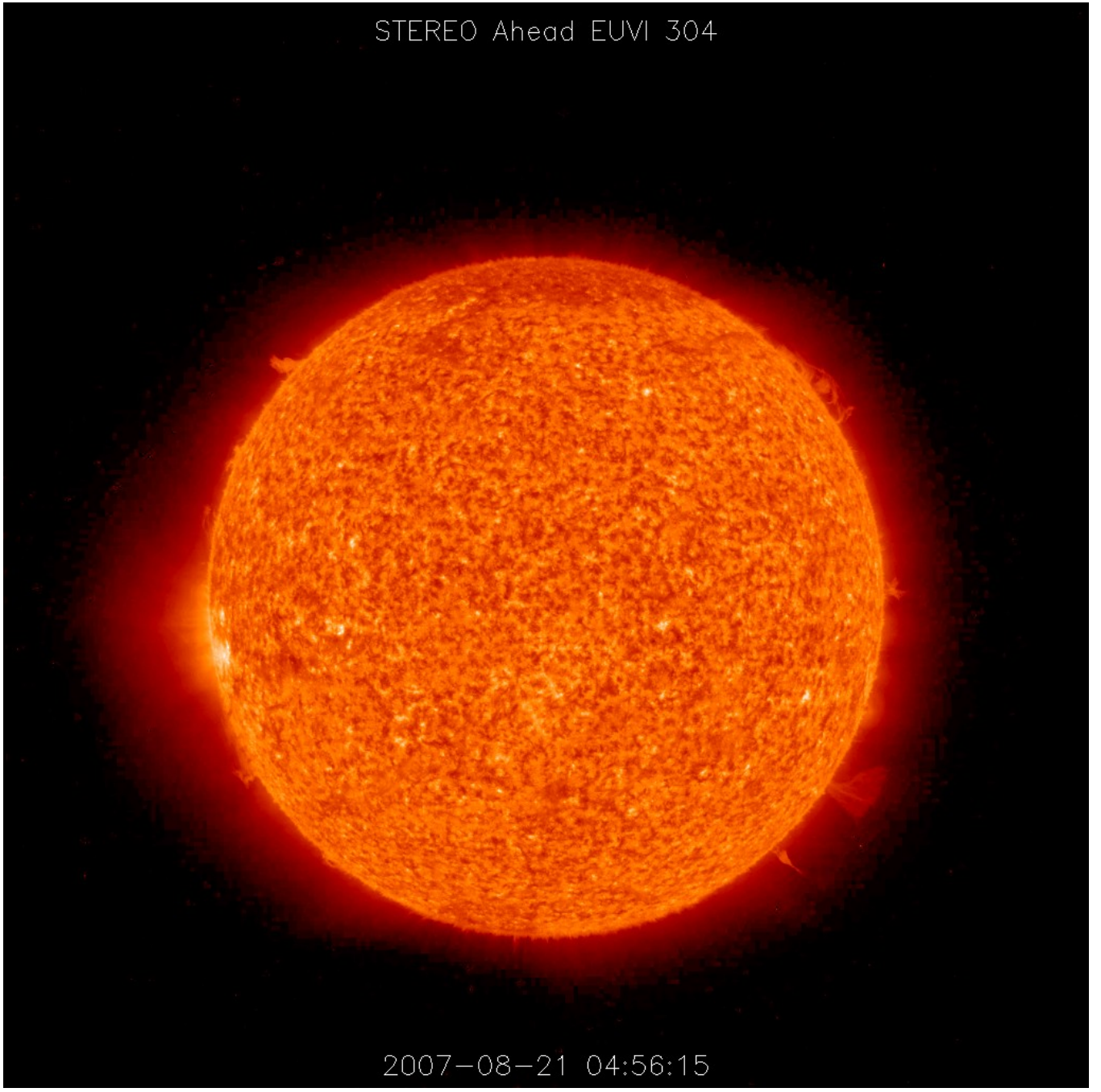

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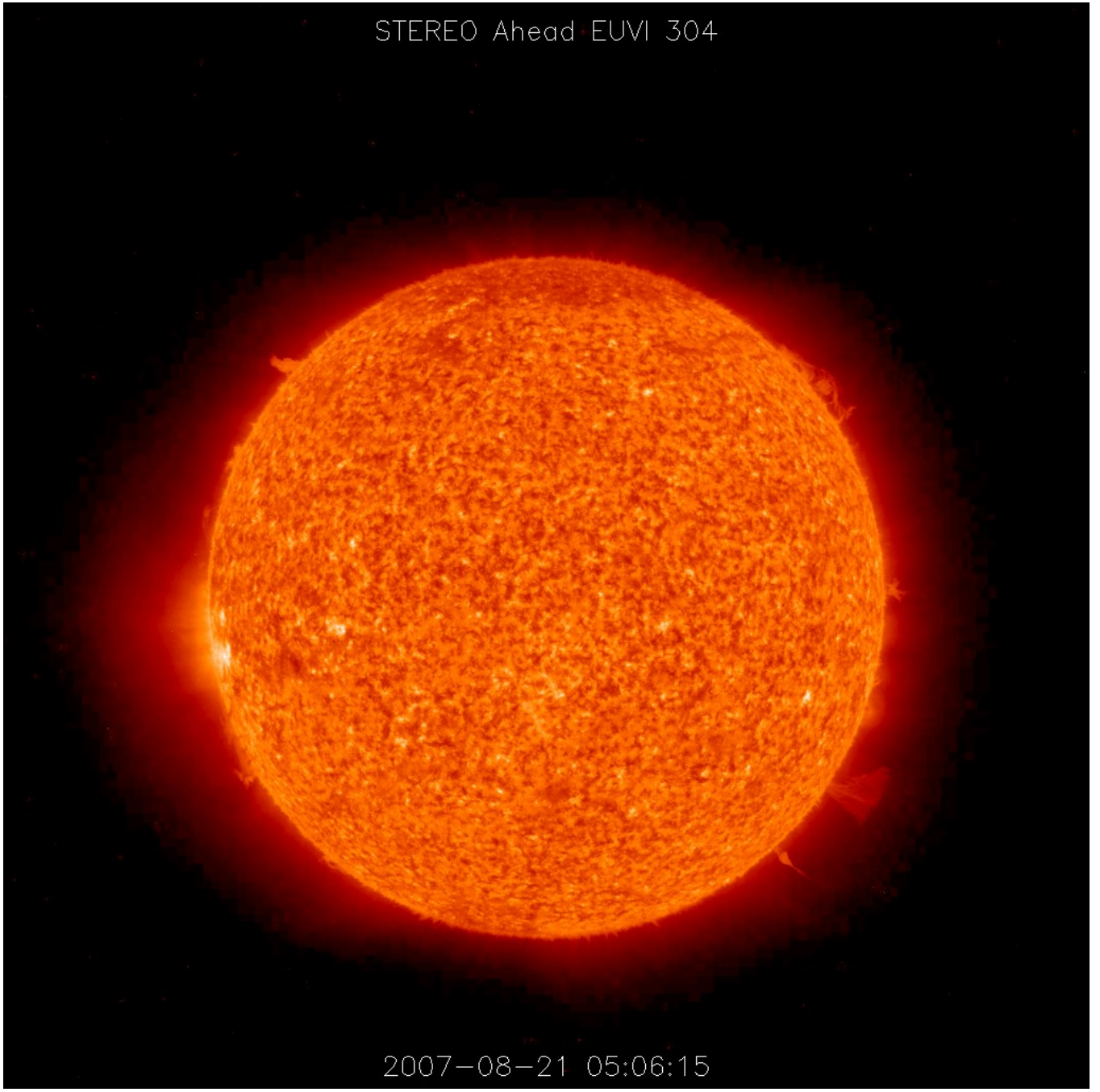
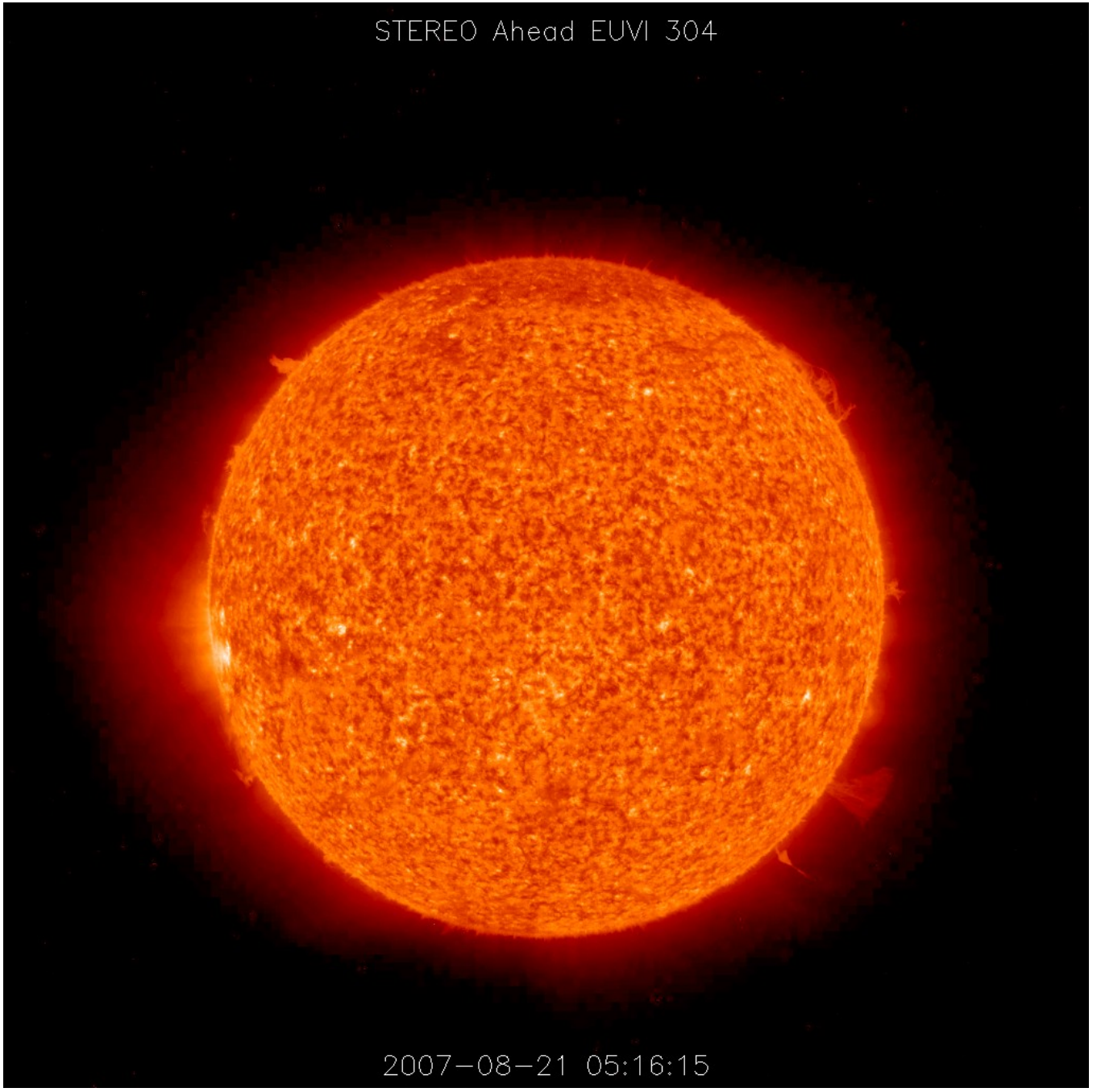


Curt A. de Koning

Geometric Localization



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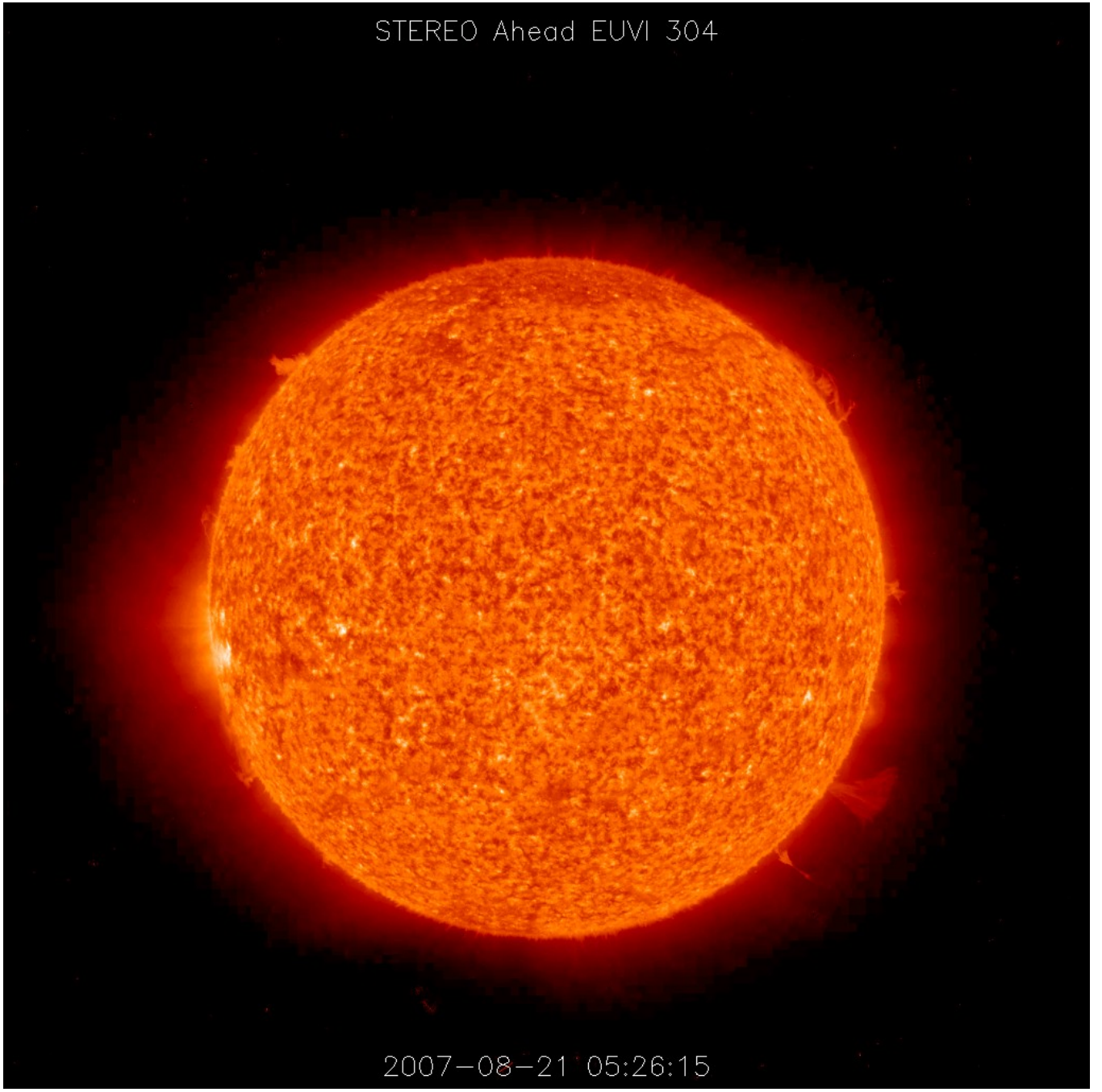
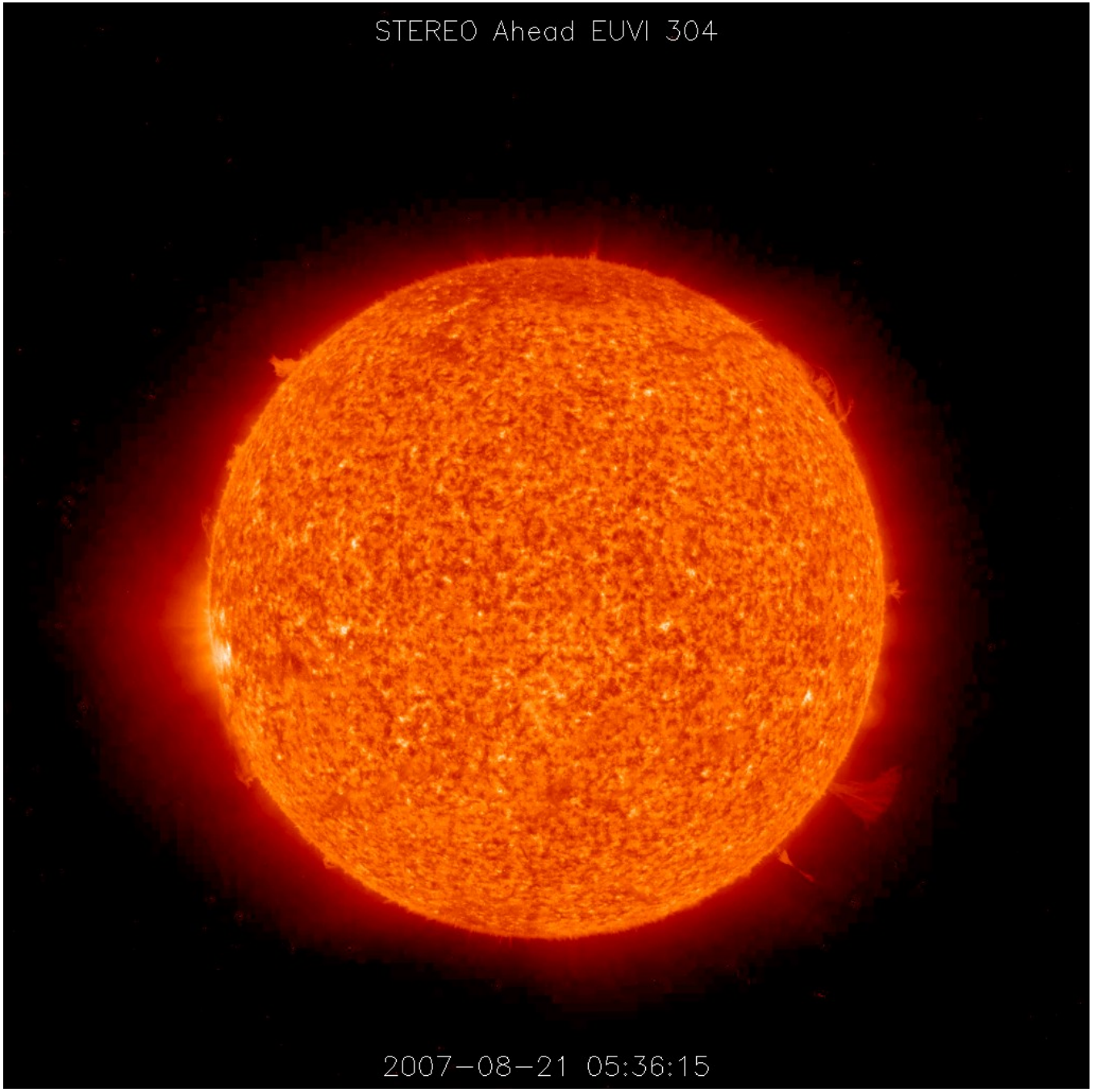
Geometric Localization



Curt A. de Koning

Geometric Localization



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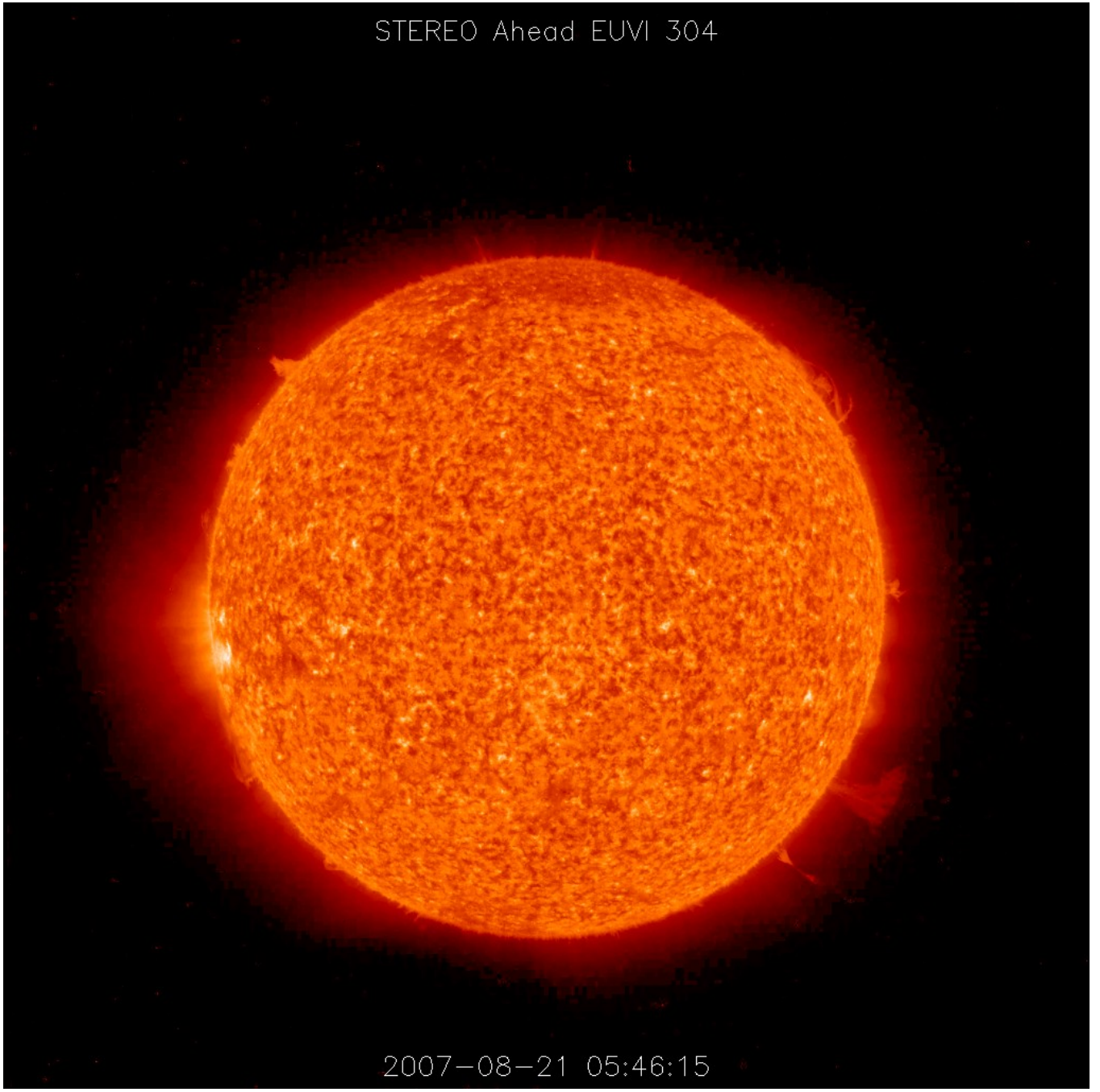
Geometric Localization



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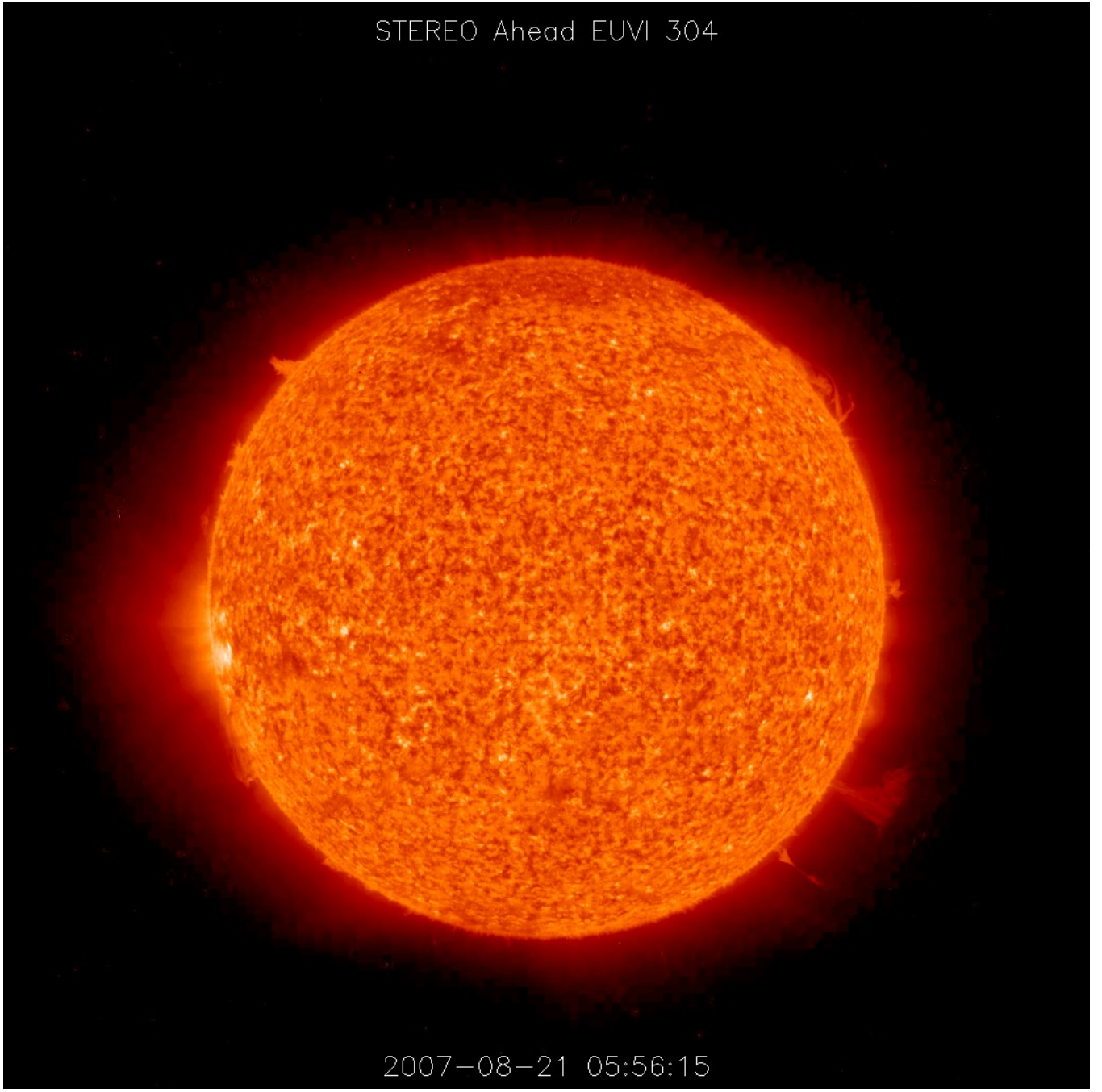
Geometric Localization



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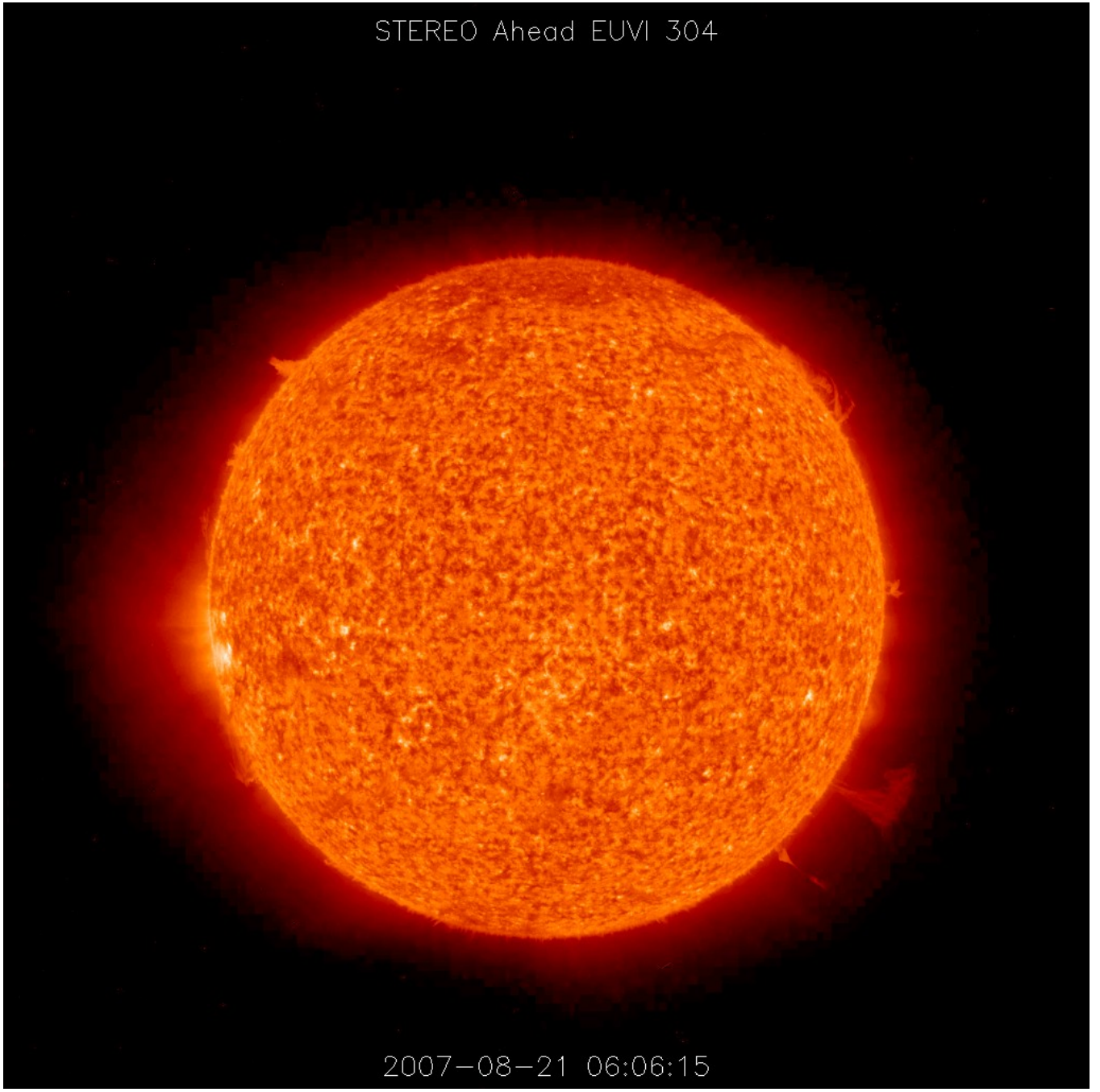
Geometric Localization



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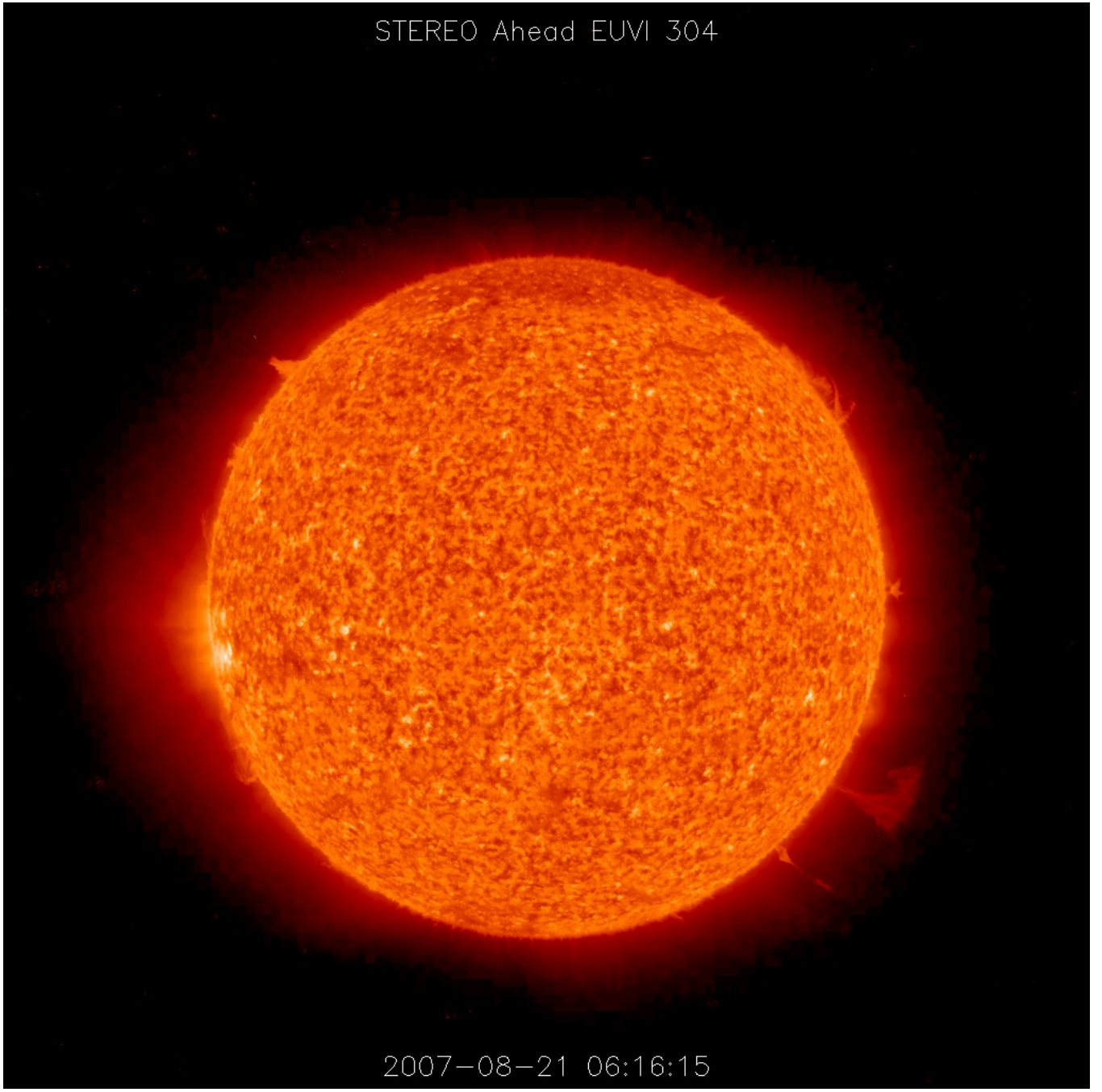
Geometric Localization



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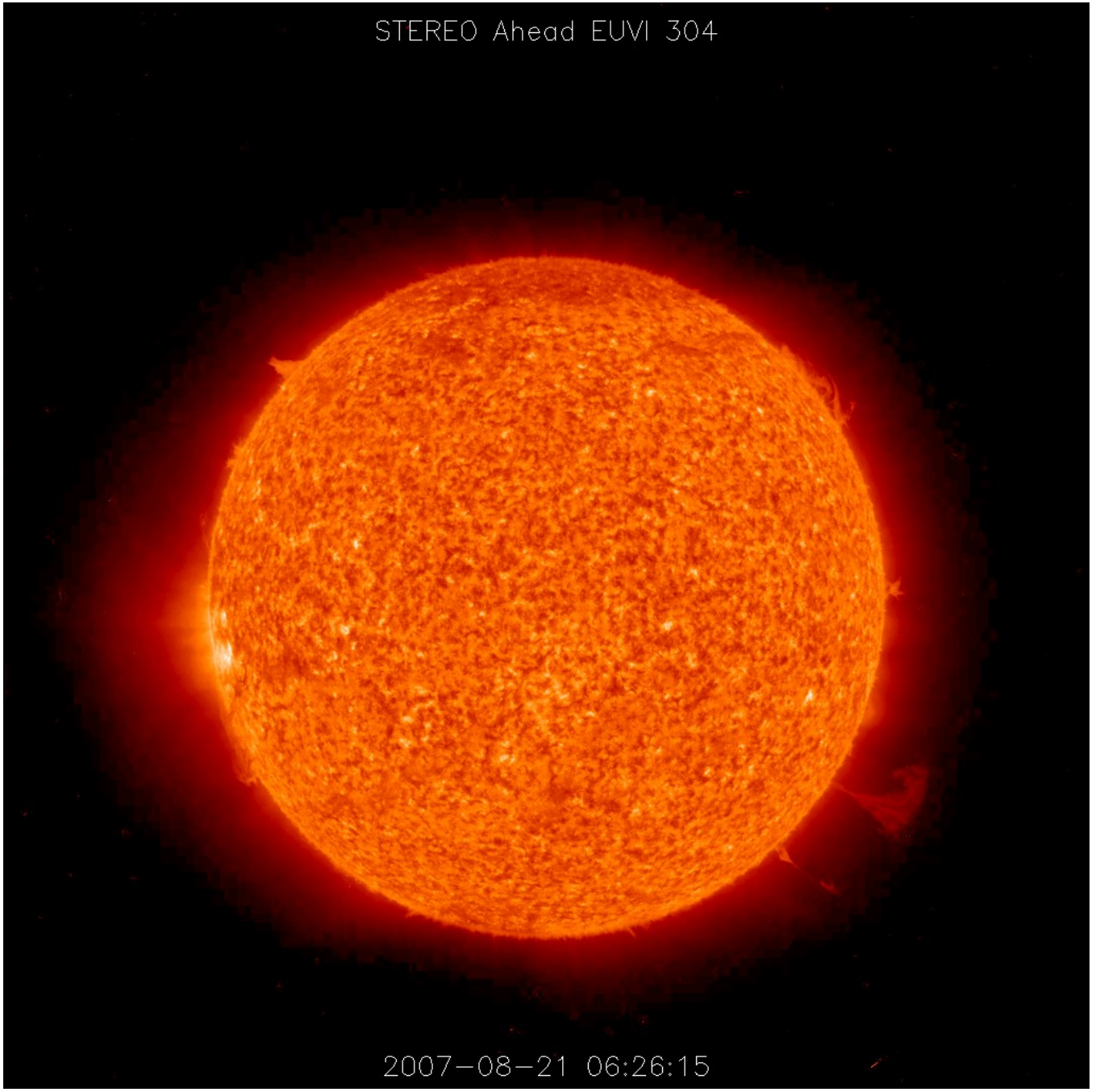

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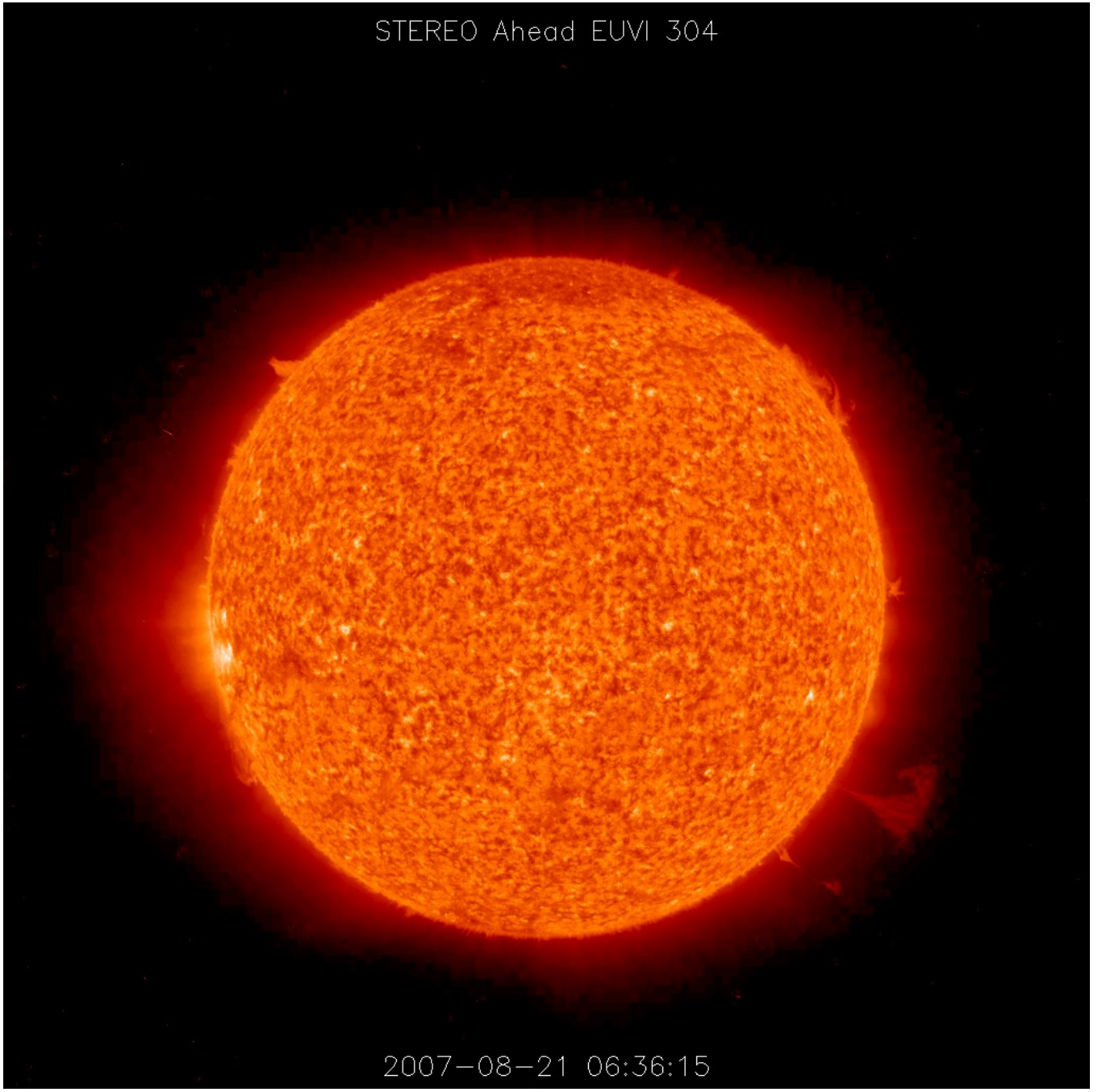

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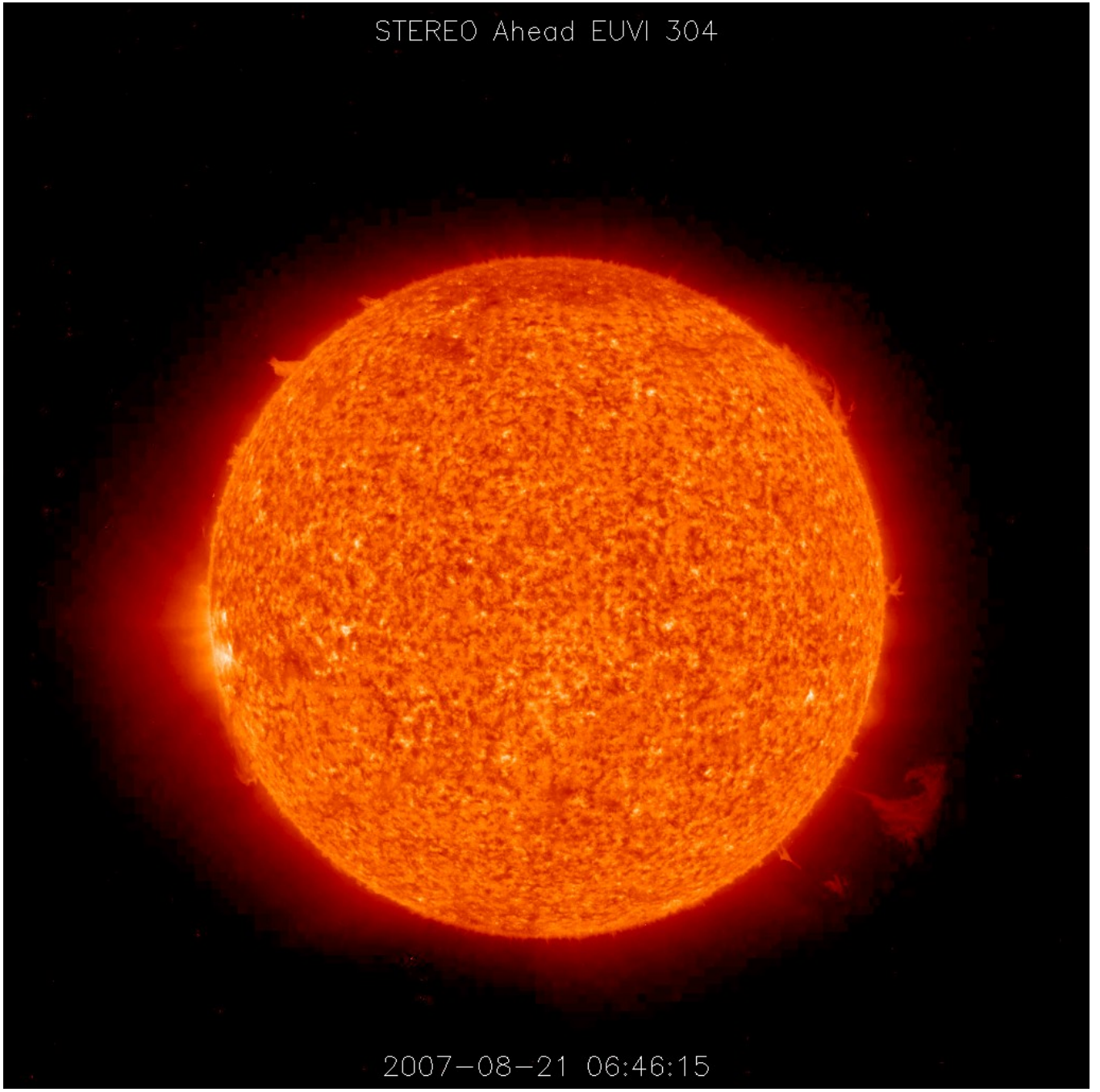

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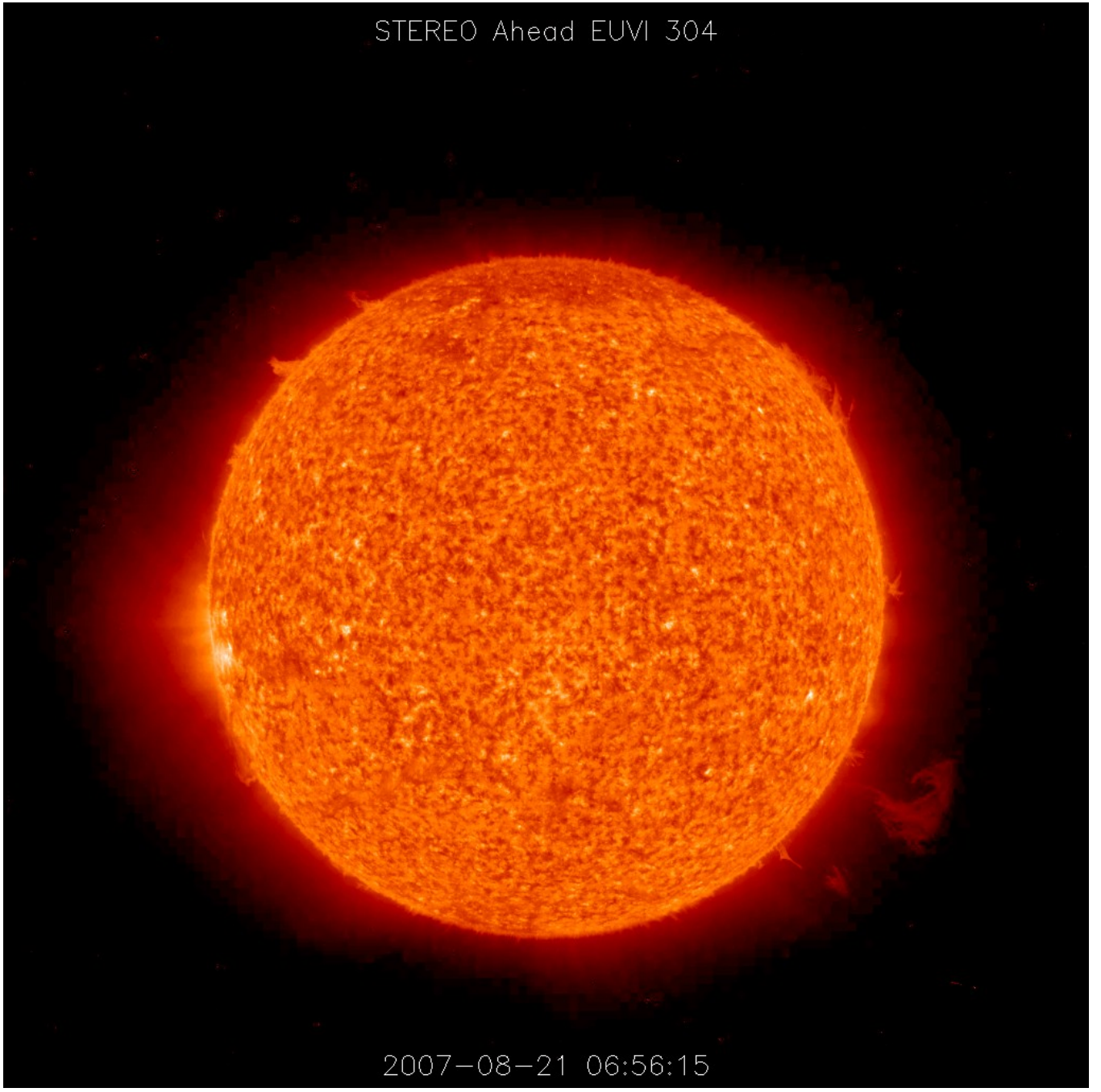

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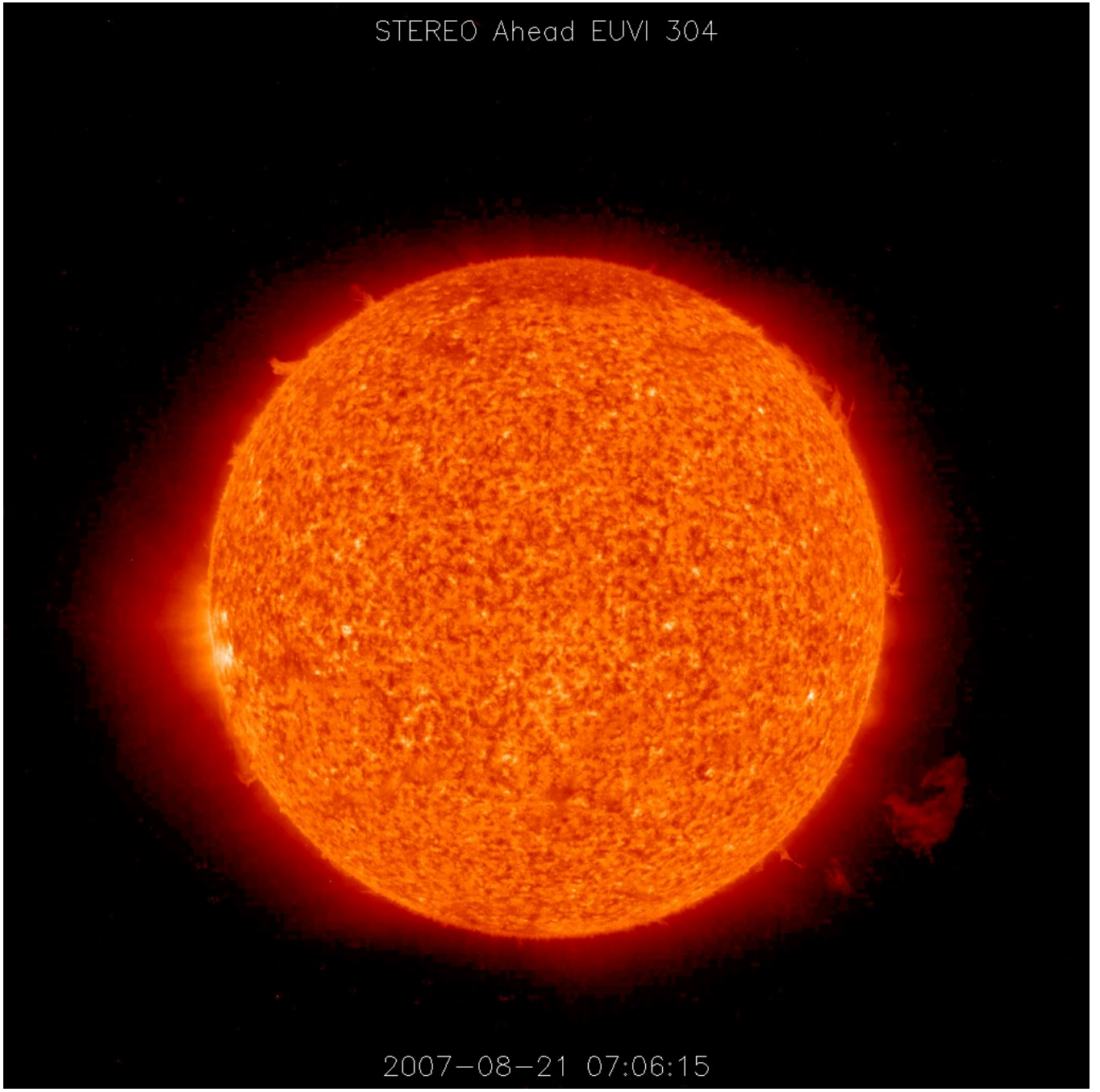

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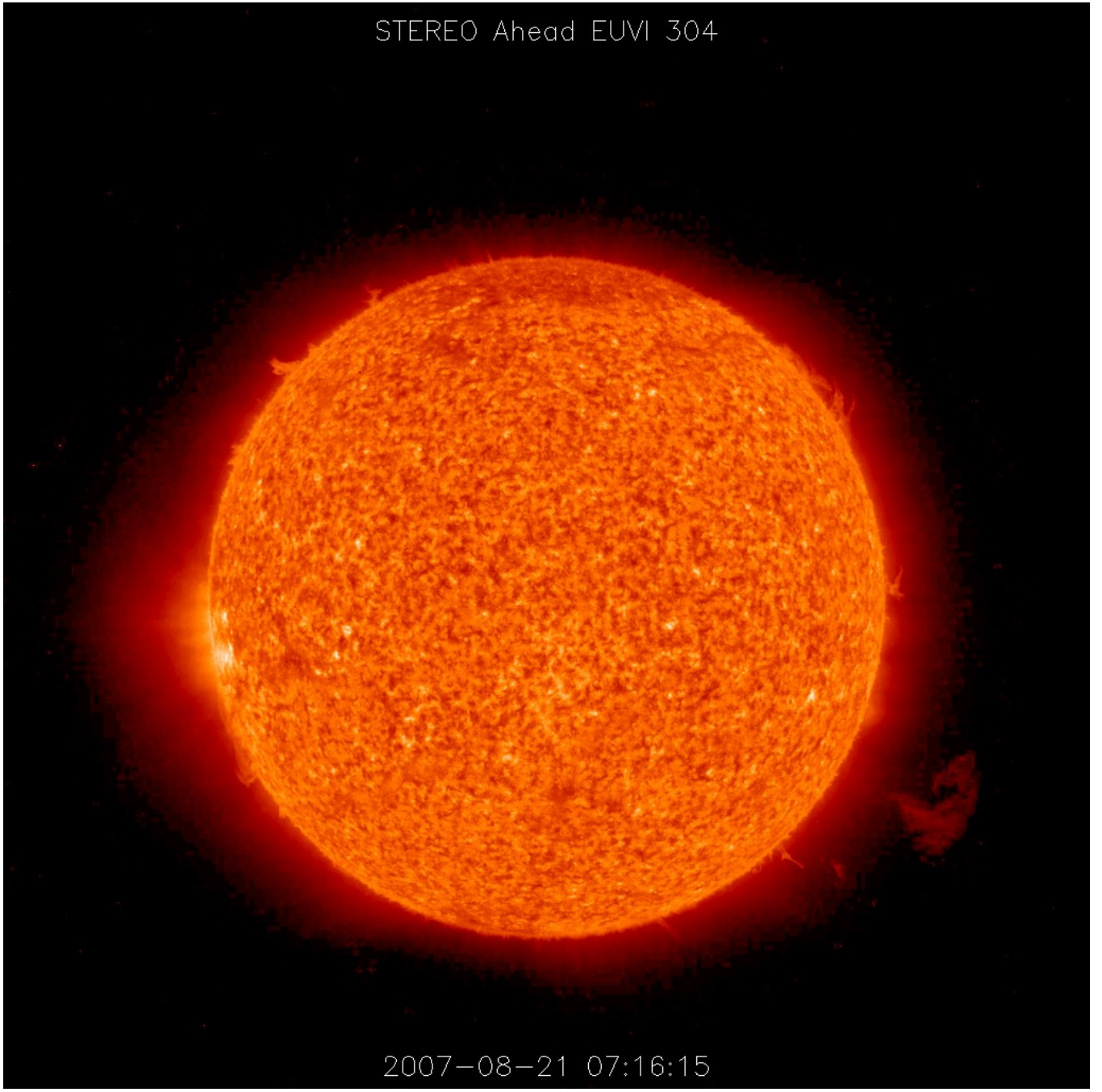

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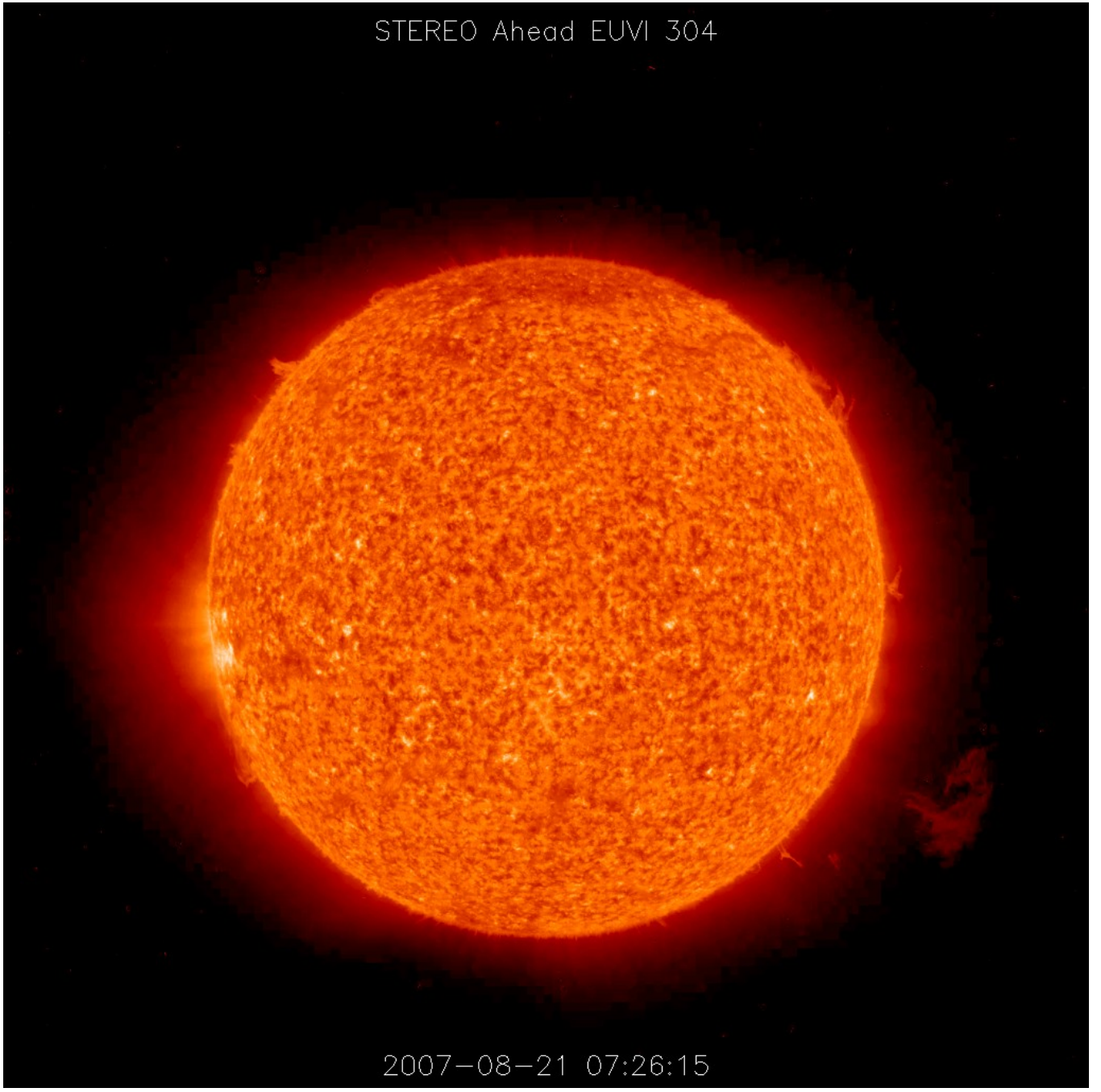

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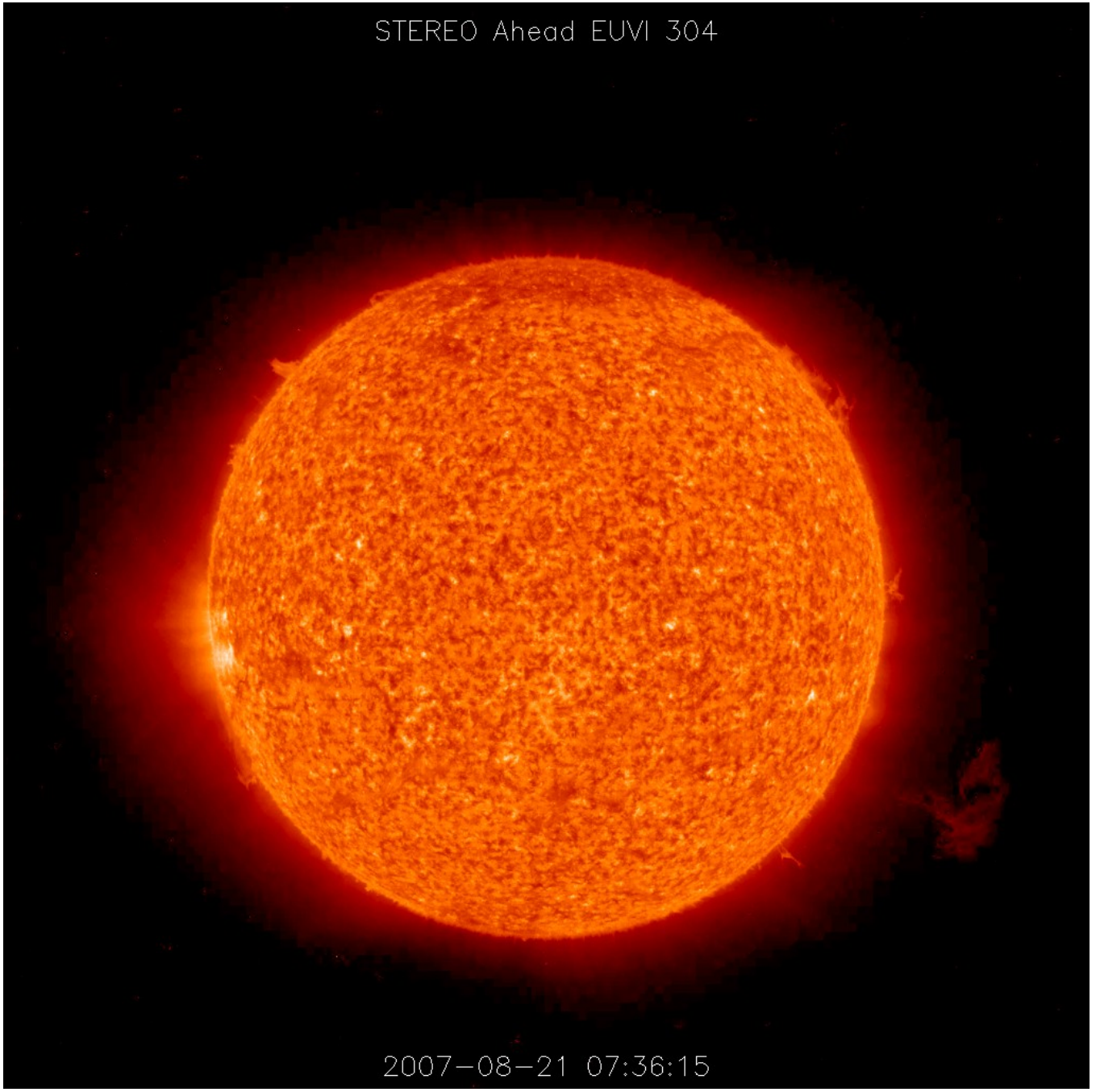

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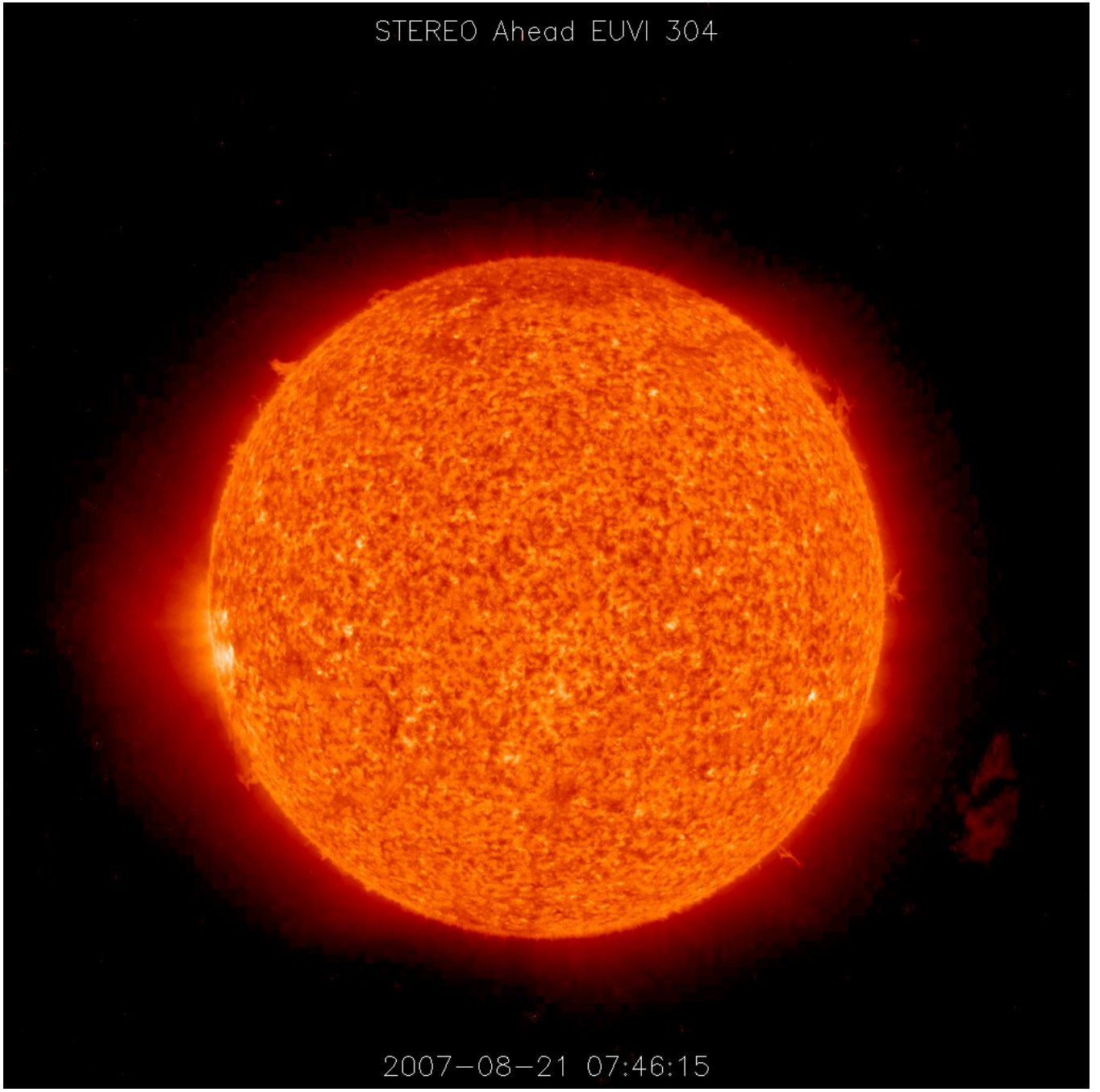

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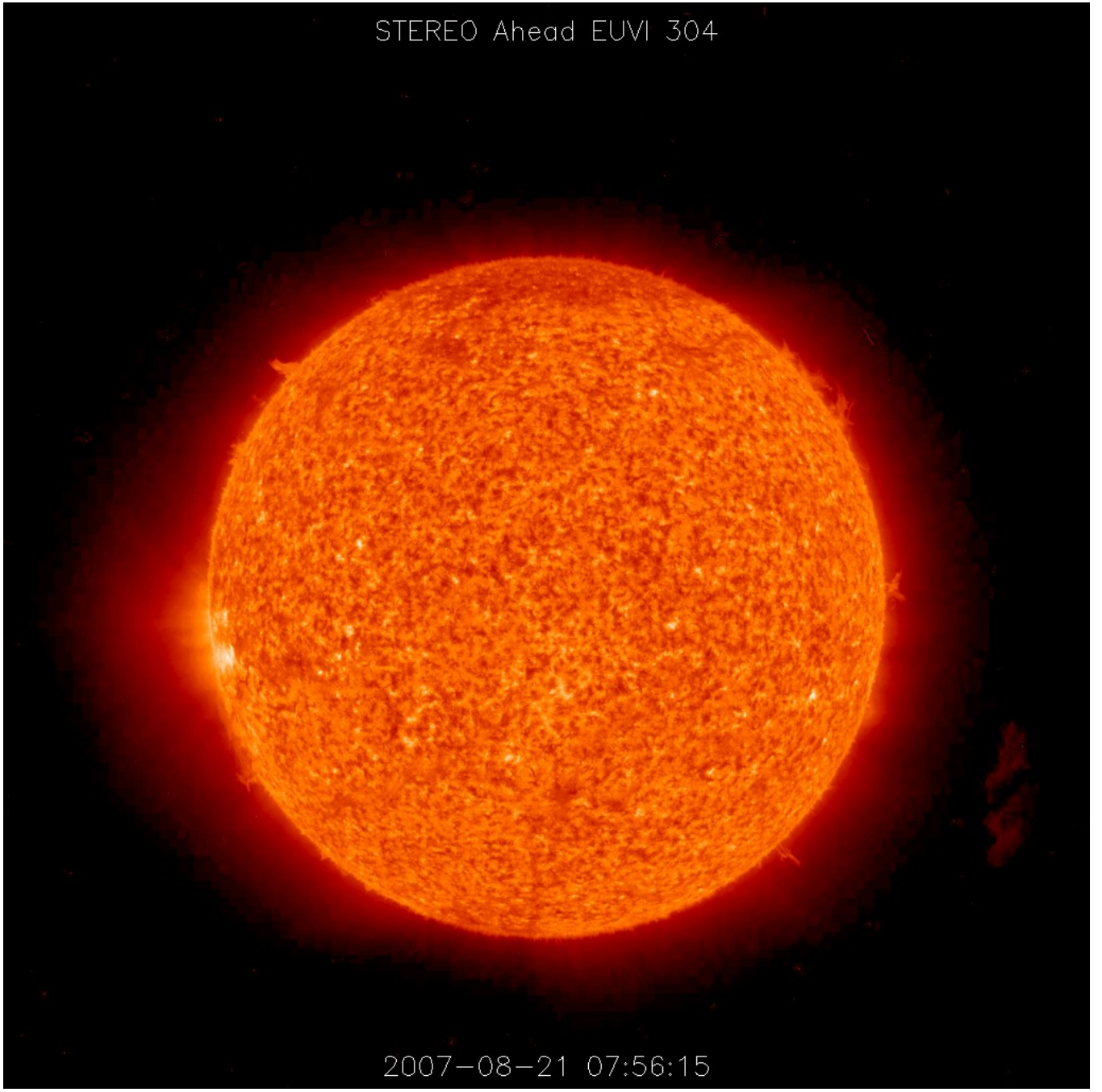

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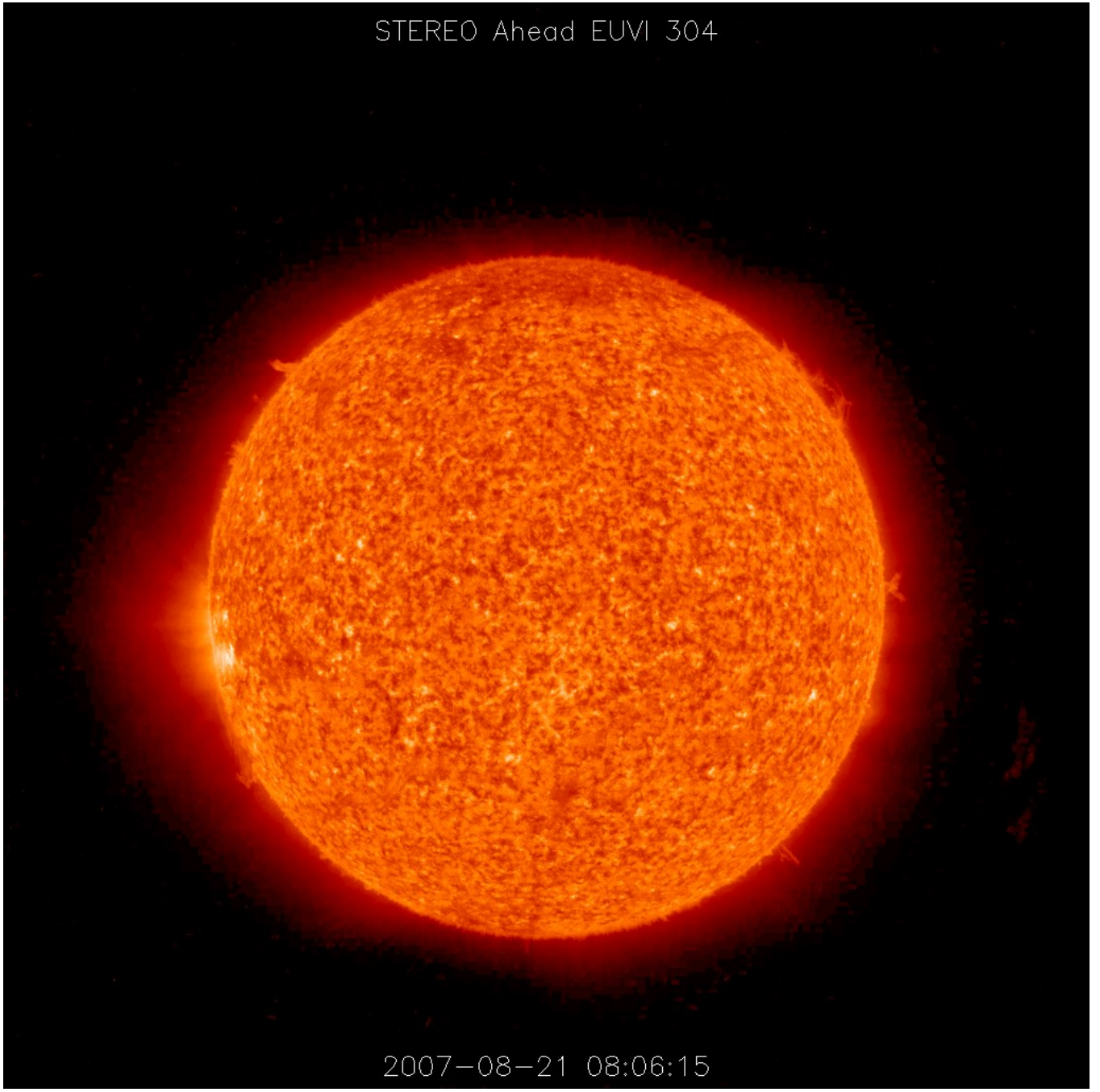

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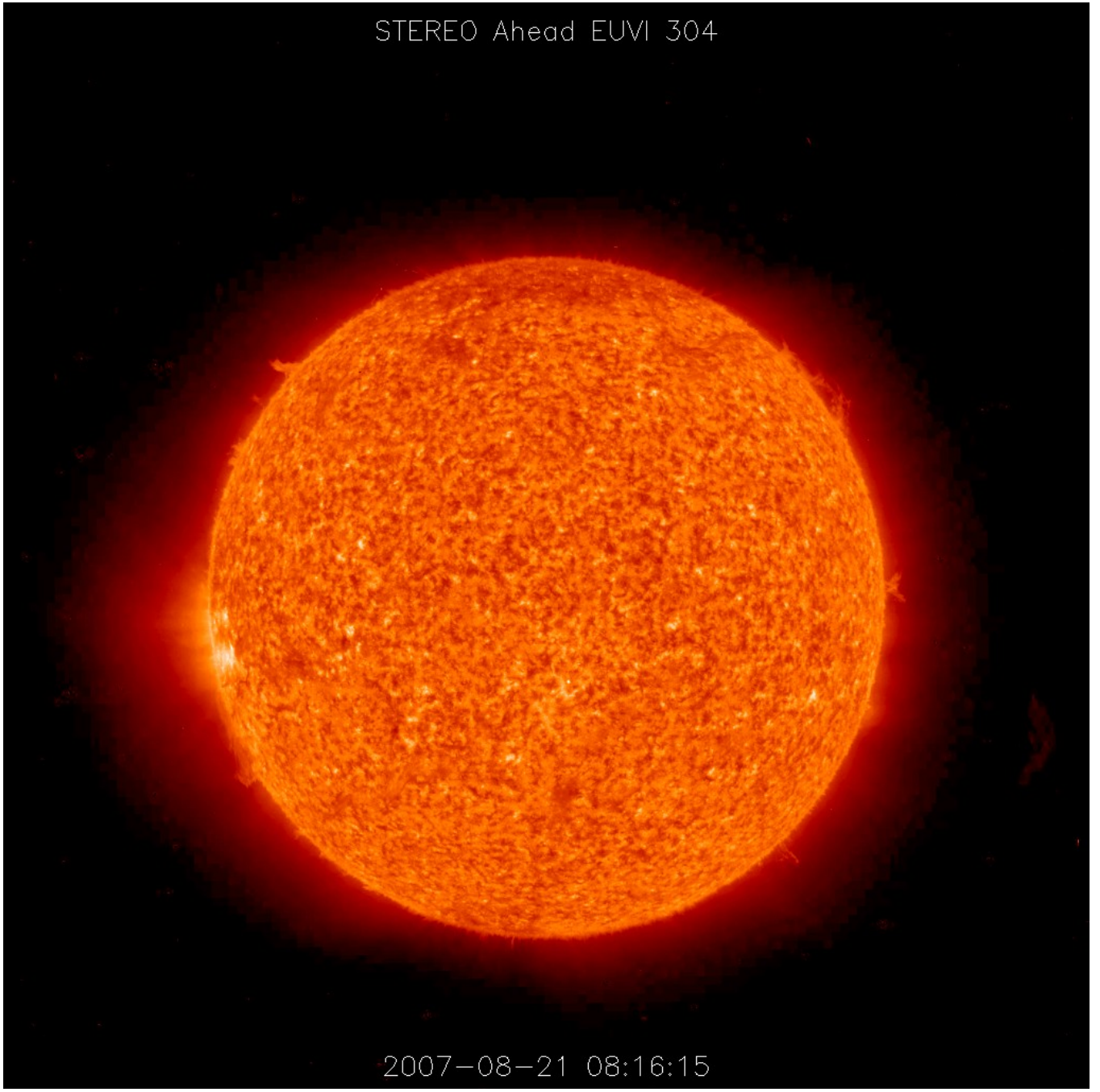
Geometric Localization



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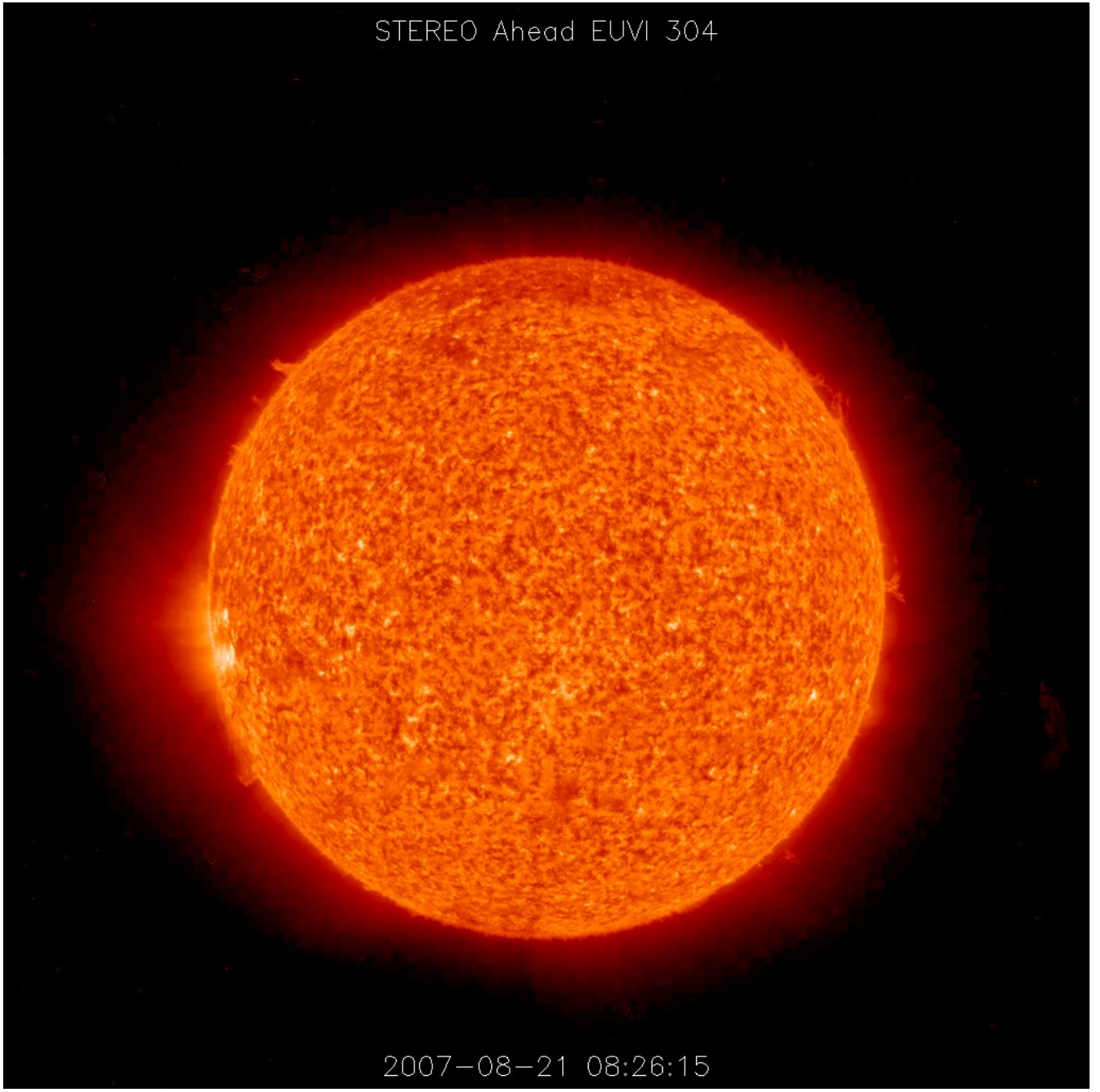

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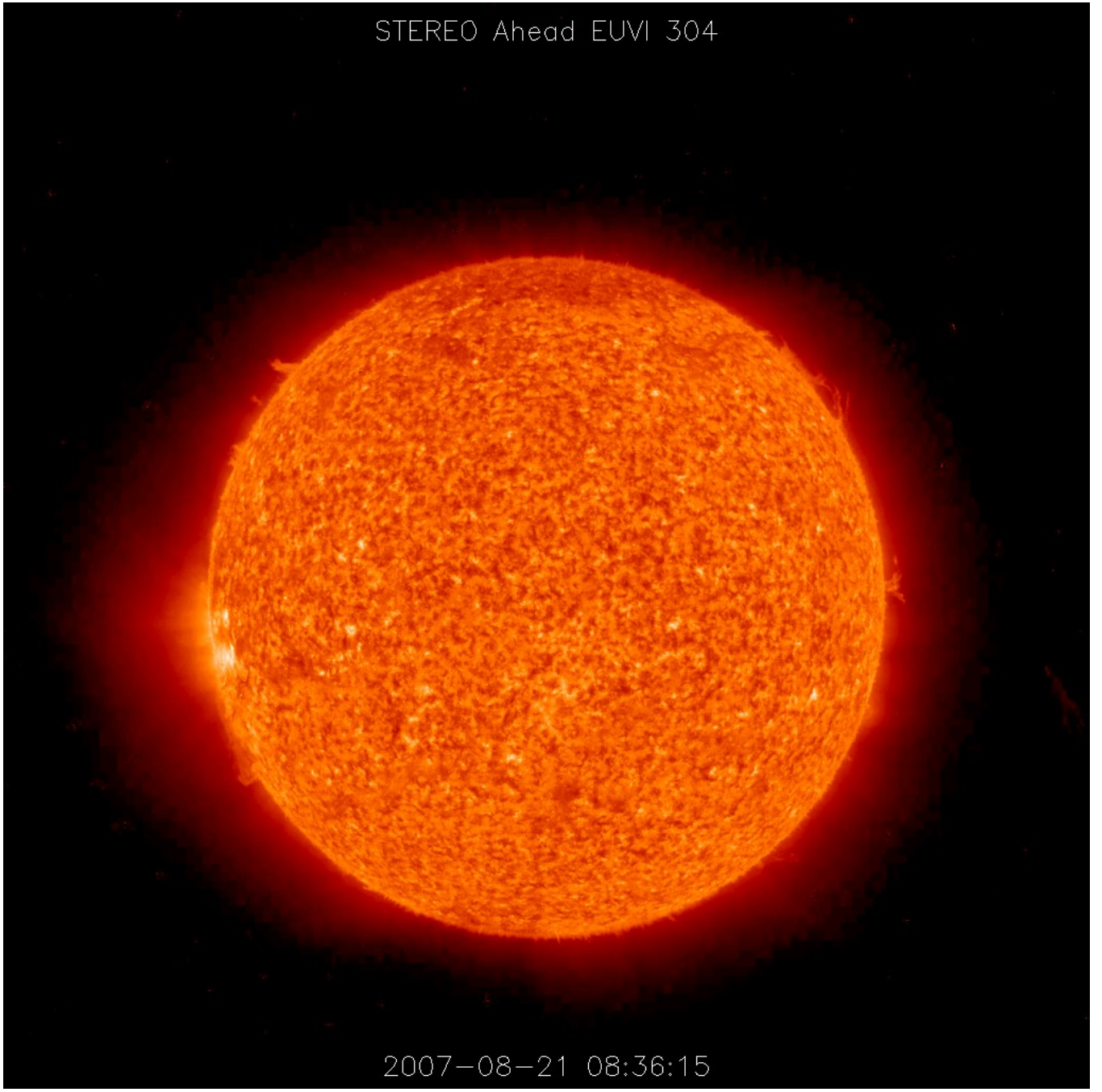

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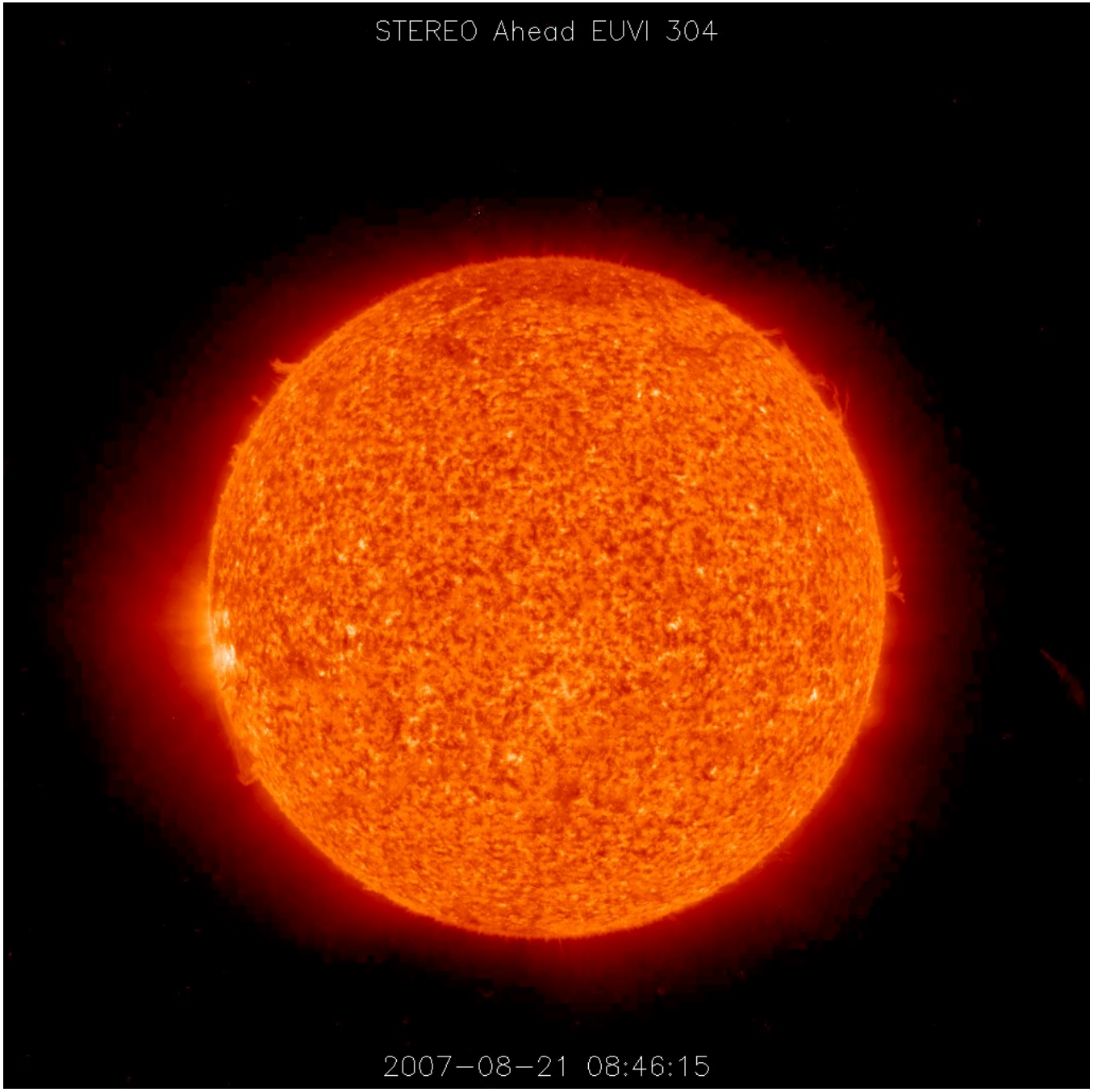

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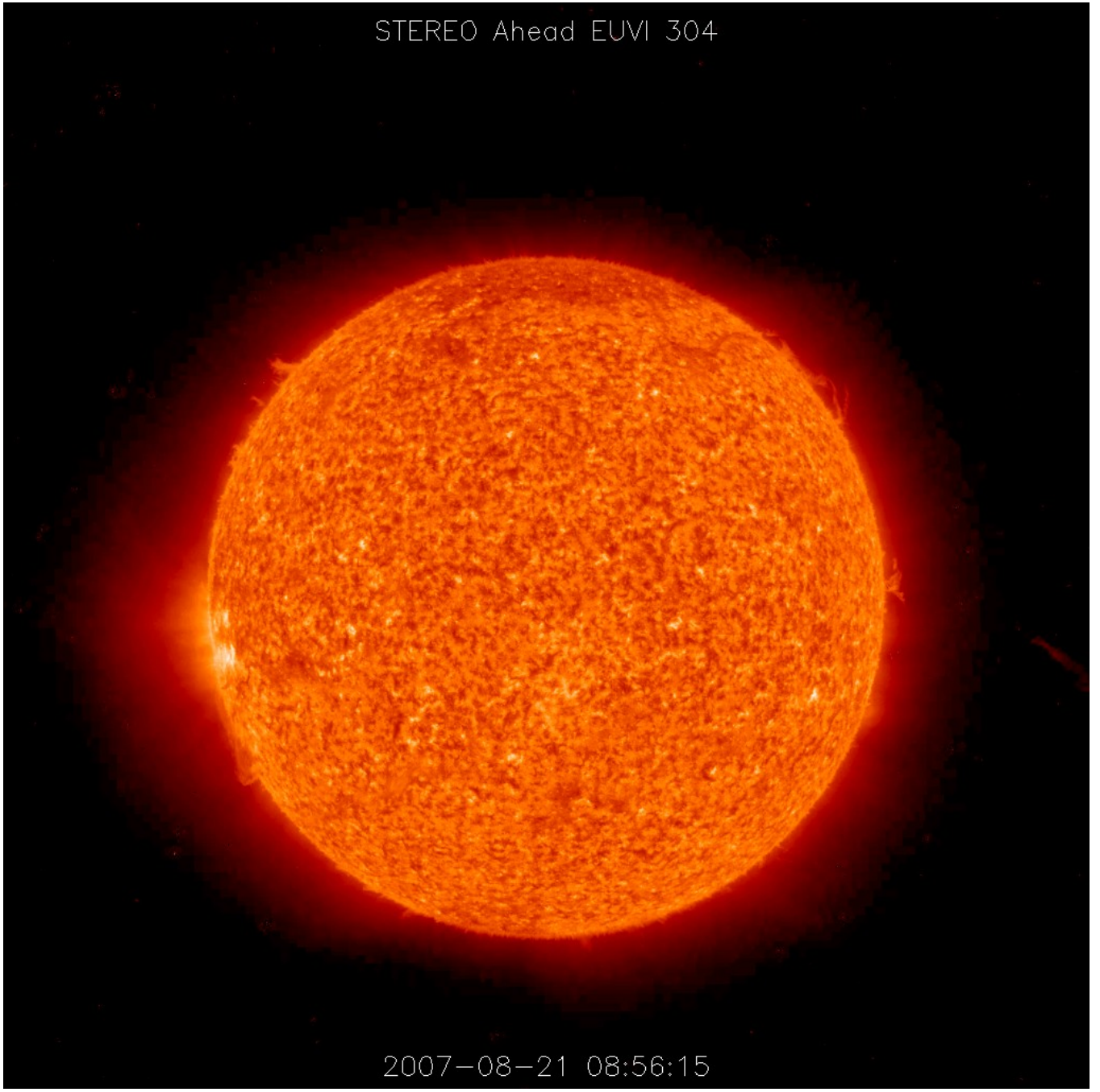

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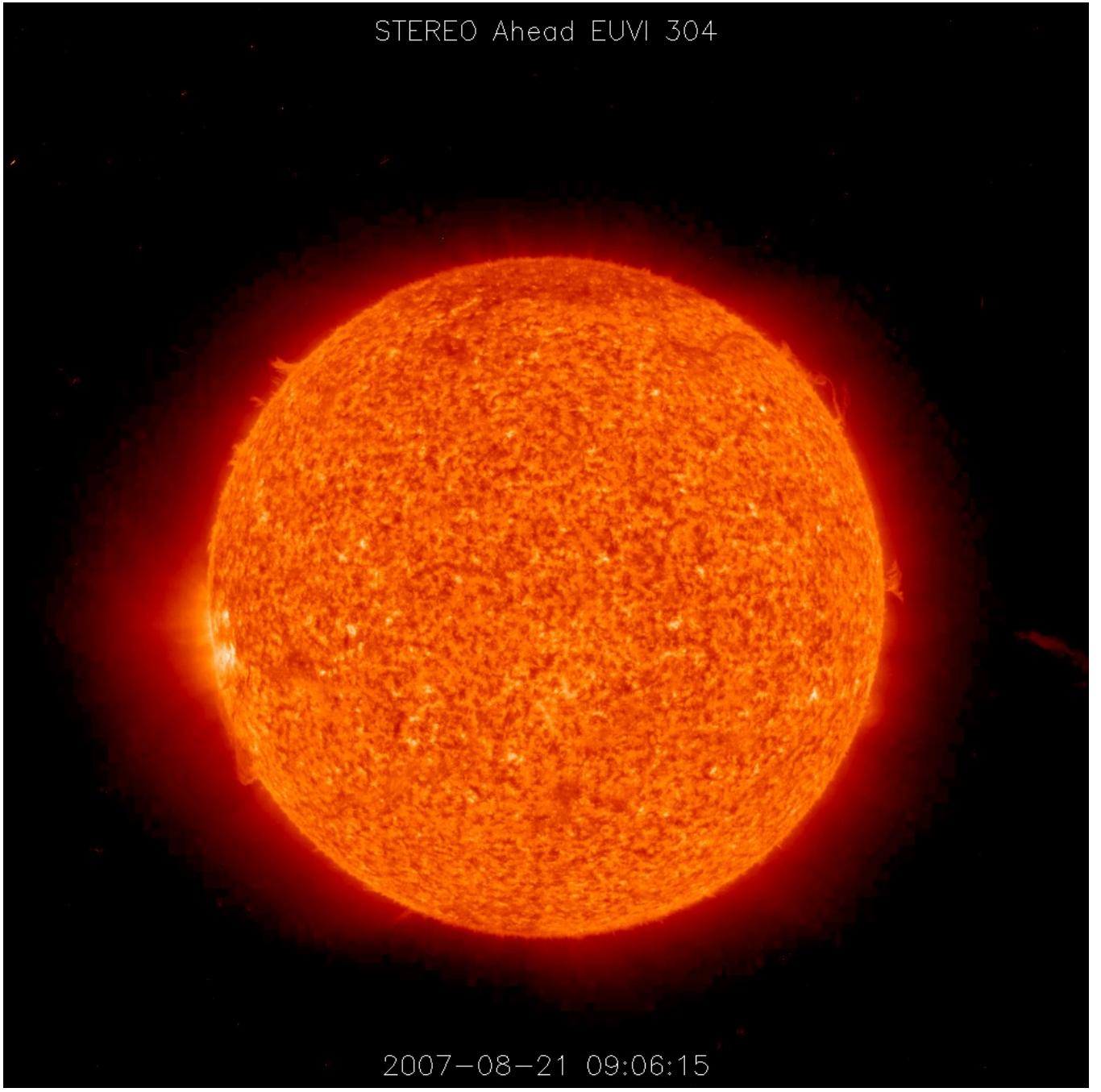

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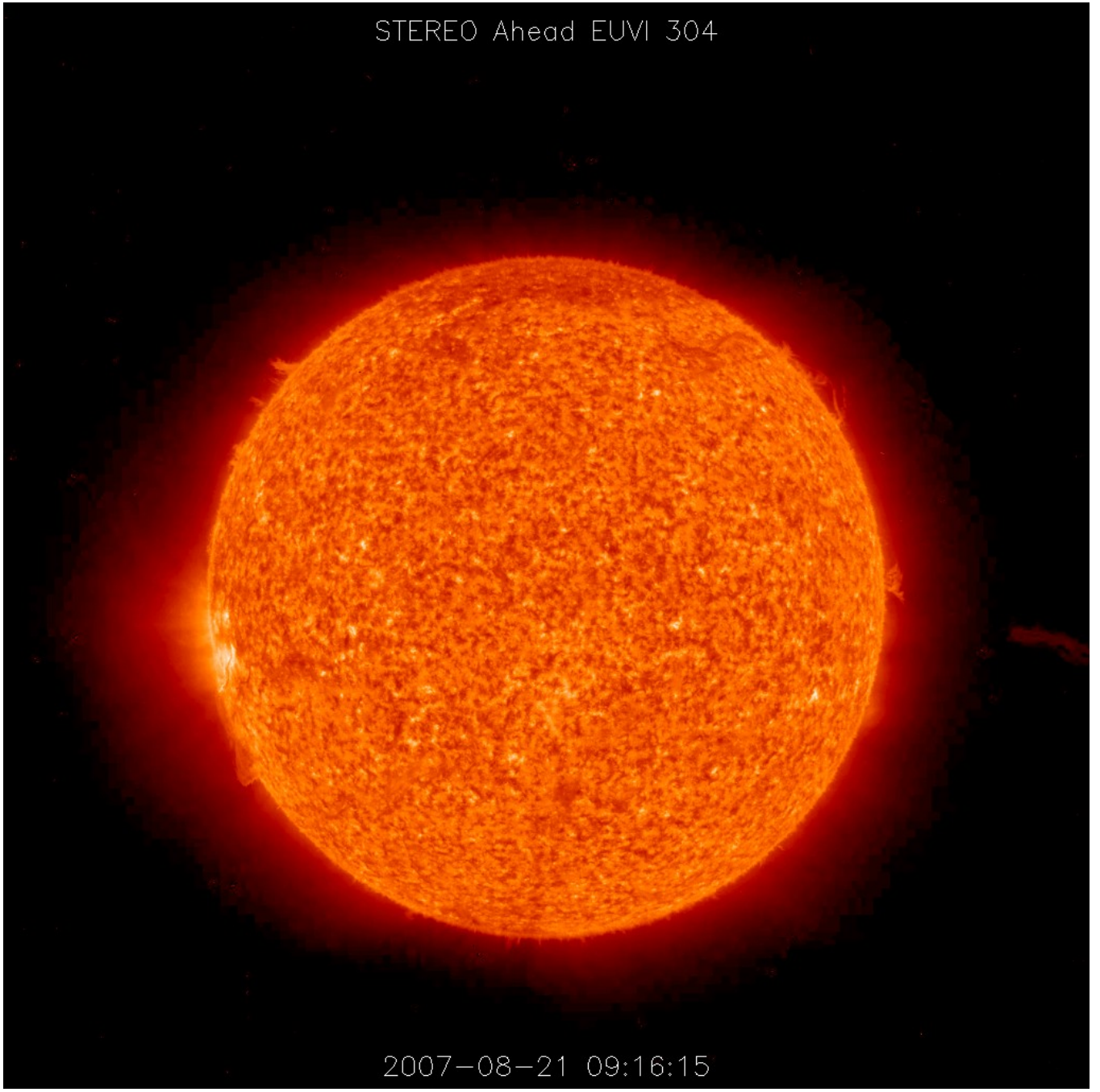

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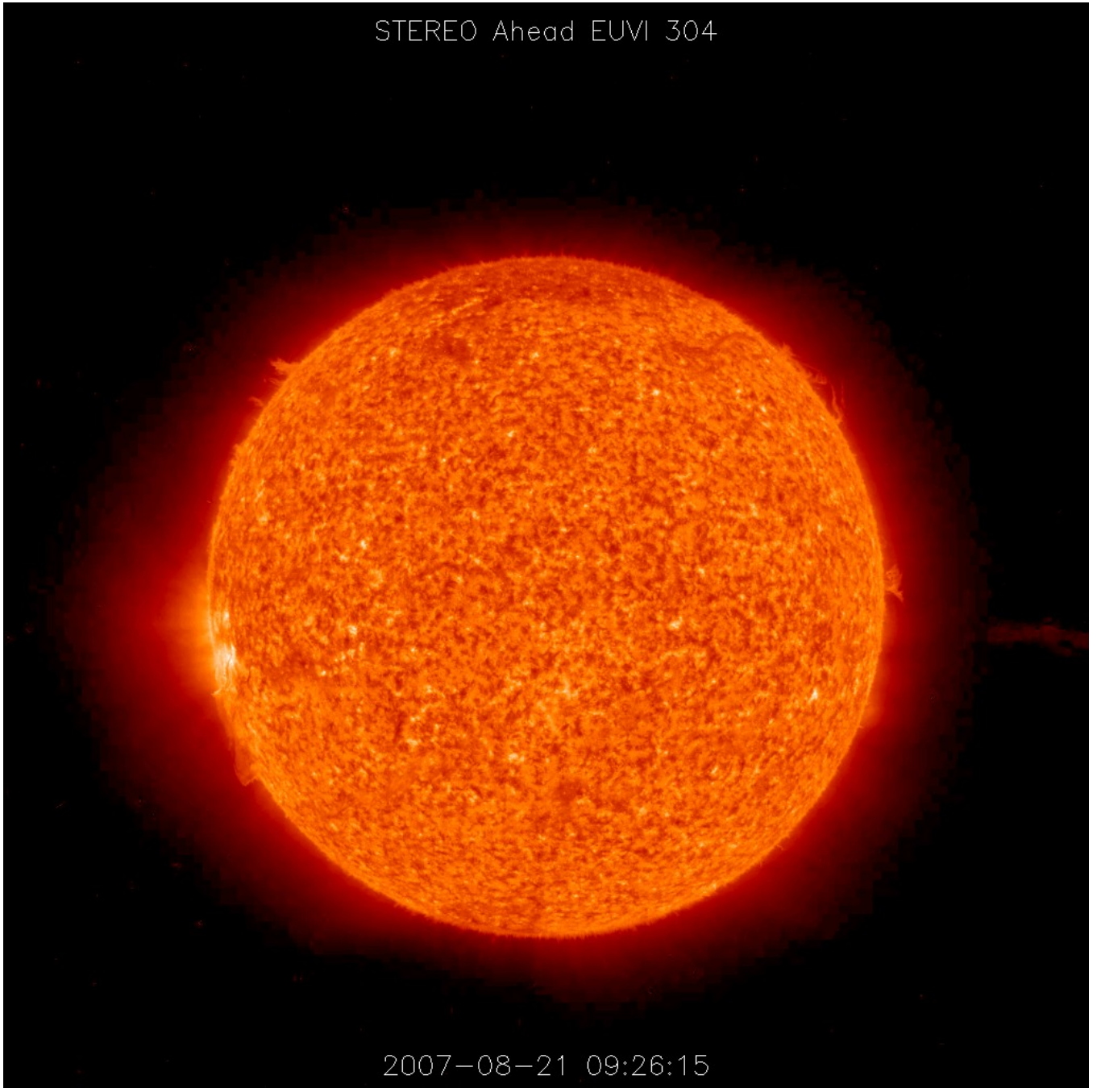

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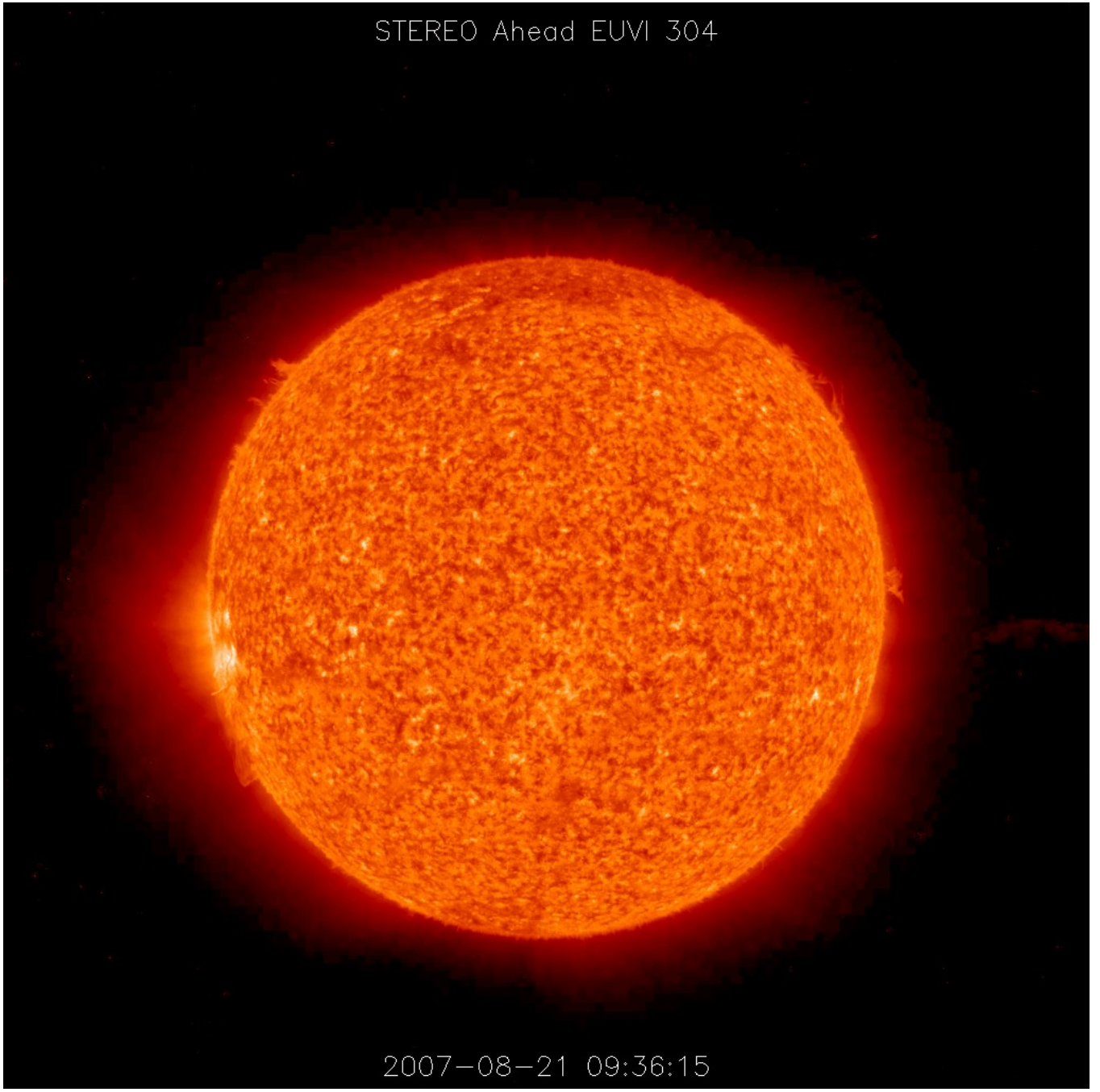

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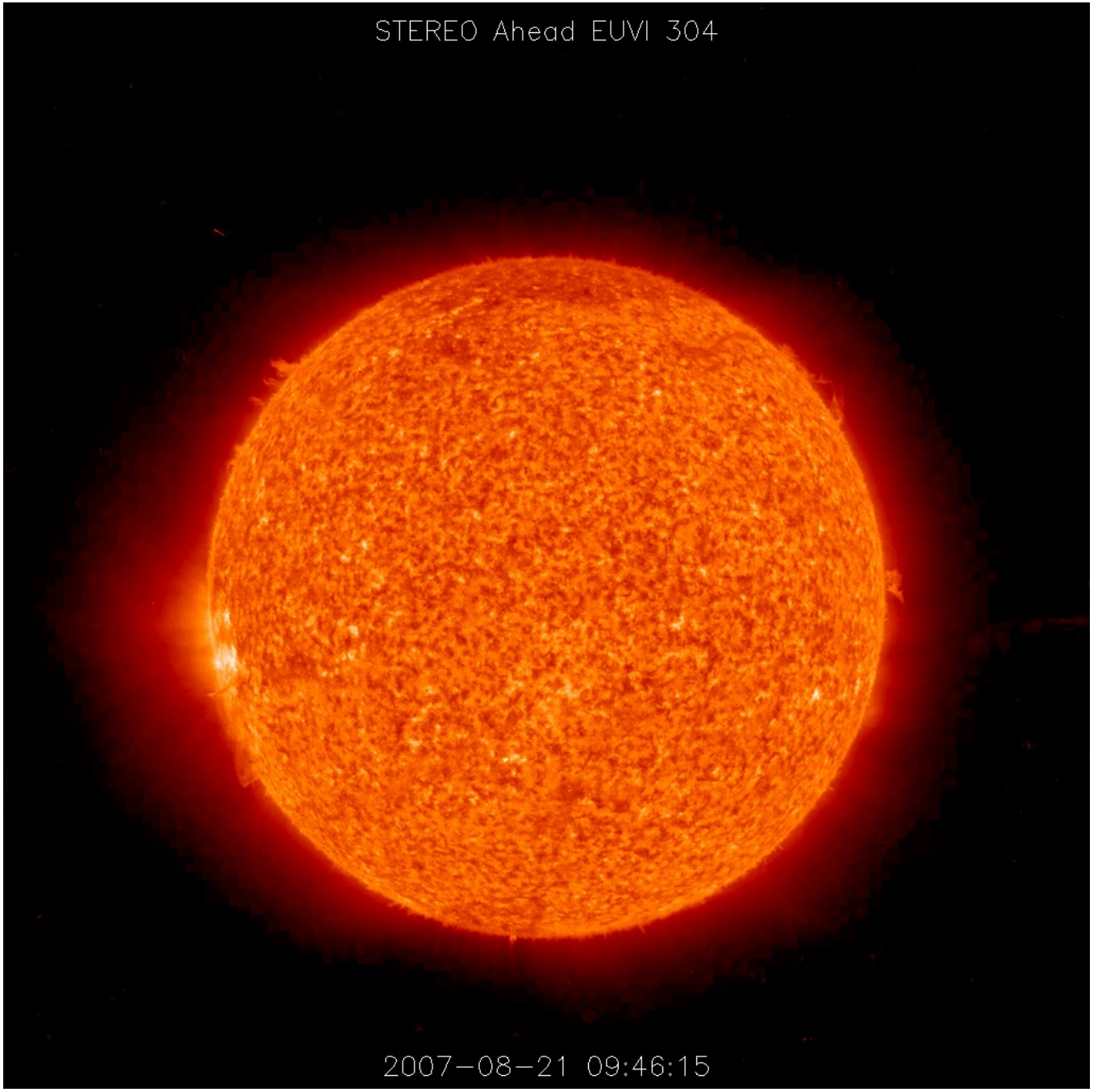
Geometric Localization



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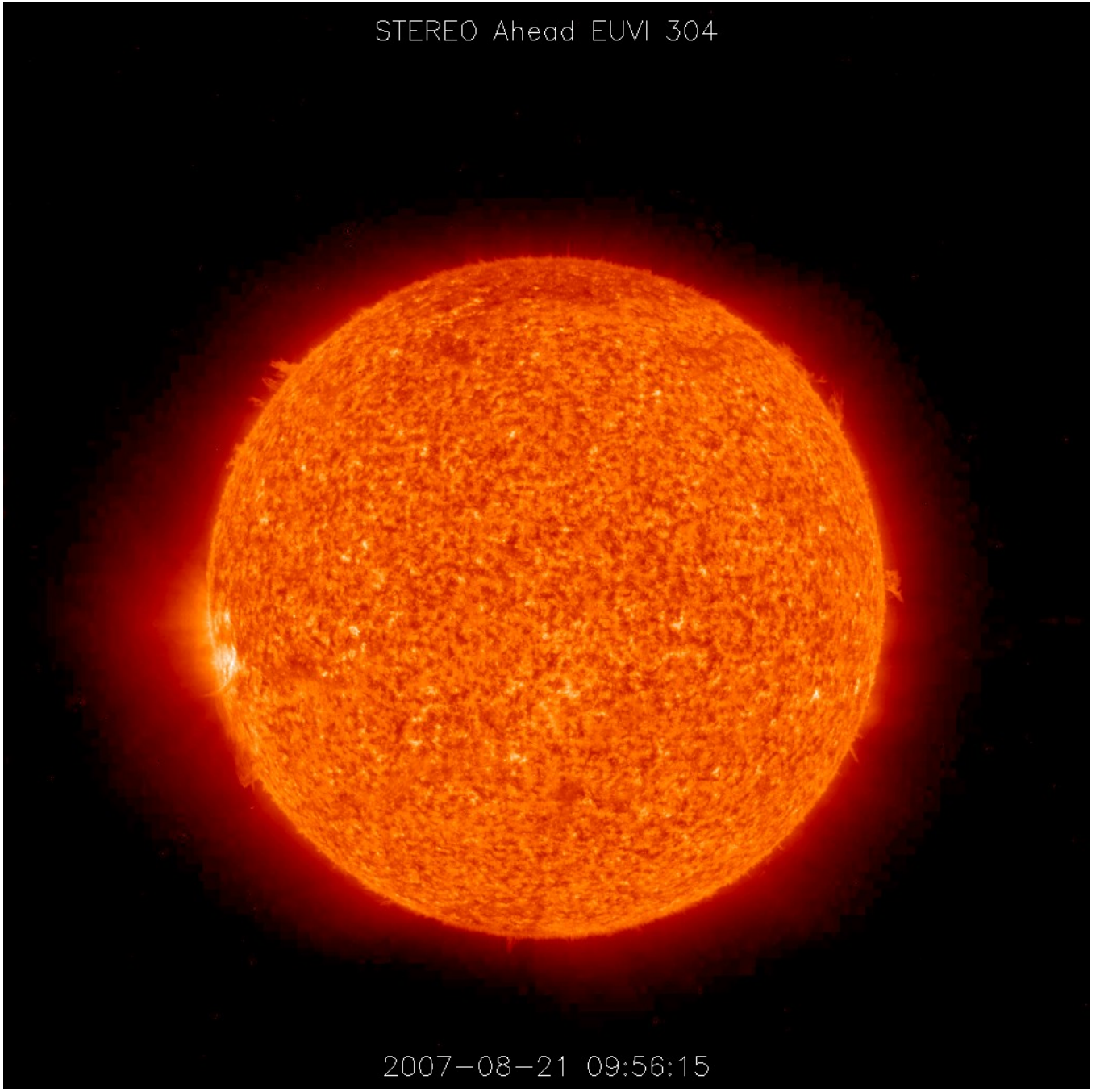

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To replay movie, poke Opus in the eye

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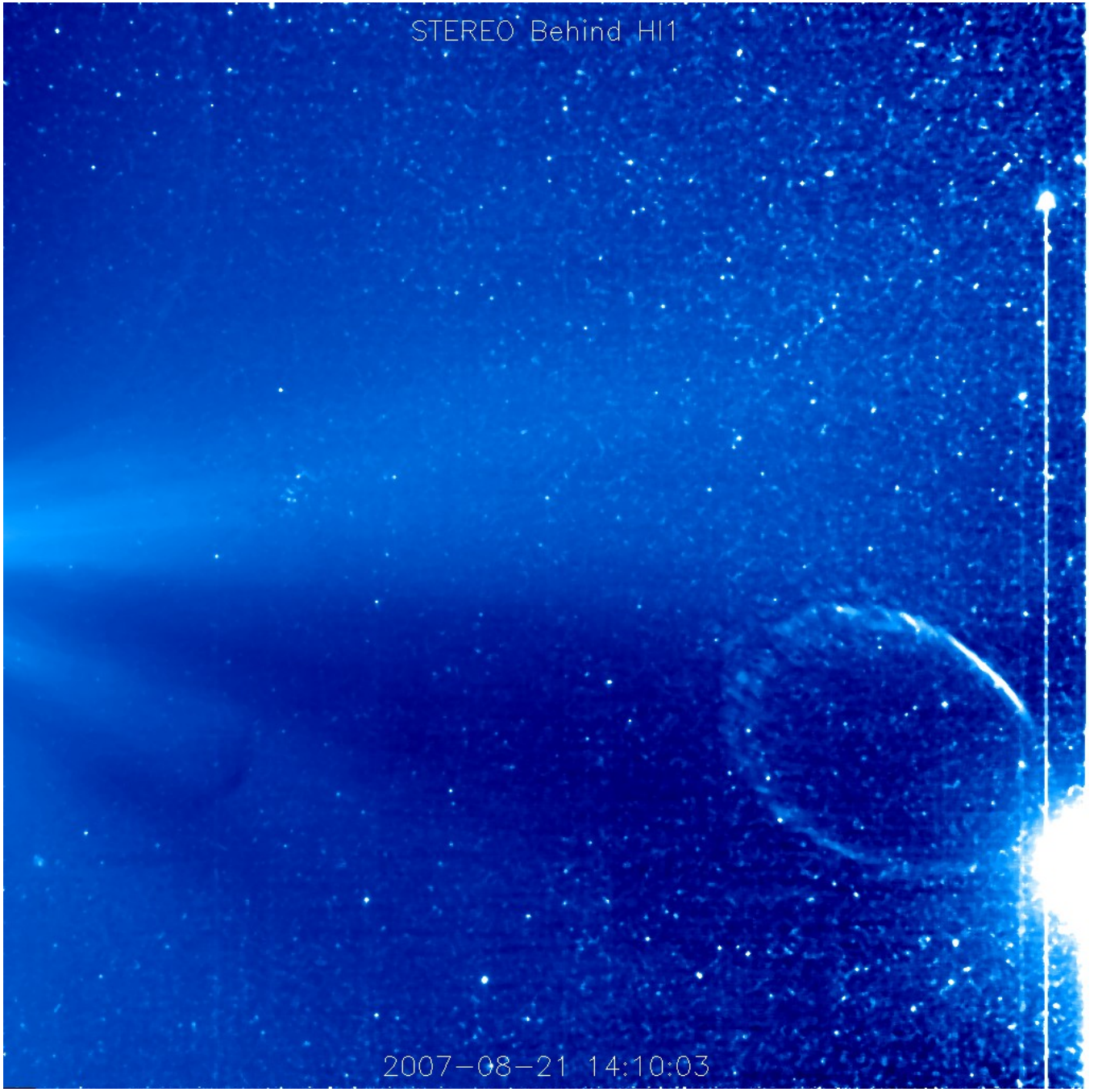
EUVI 304 Å observations

This bandpass is sensitive to the He II singly ionized state of helium, at a characteristic temperature of about 8×10^4 K

- loop slowly started rising between 0300–0400
- loop clearly expanding between 0400–0500
- loop appears to lift-off from Sun at 0636

ICME may be He rich

Geometric Localization



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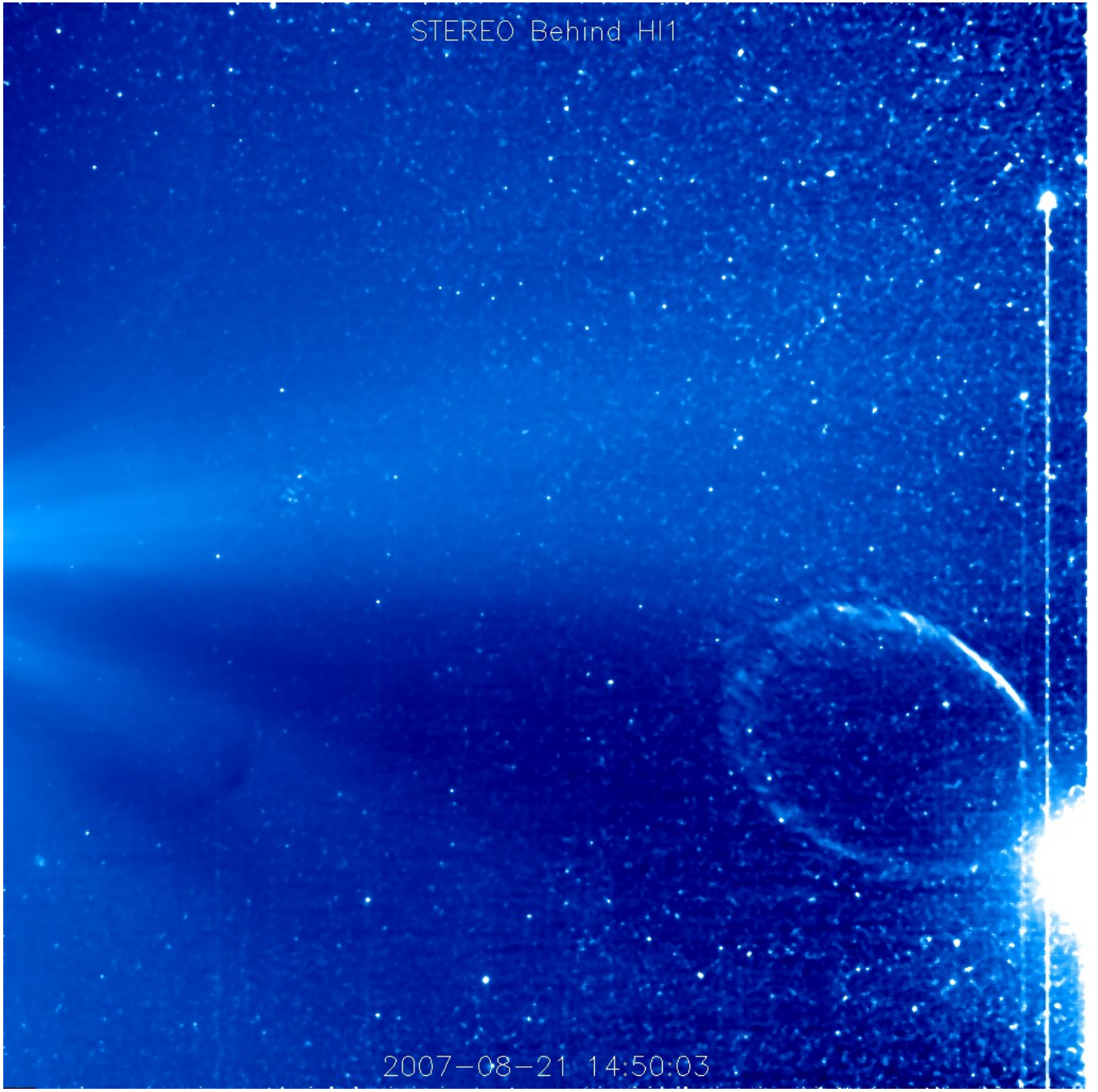
Geometric Localization



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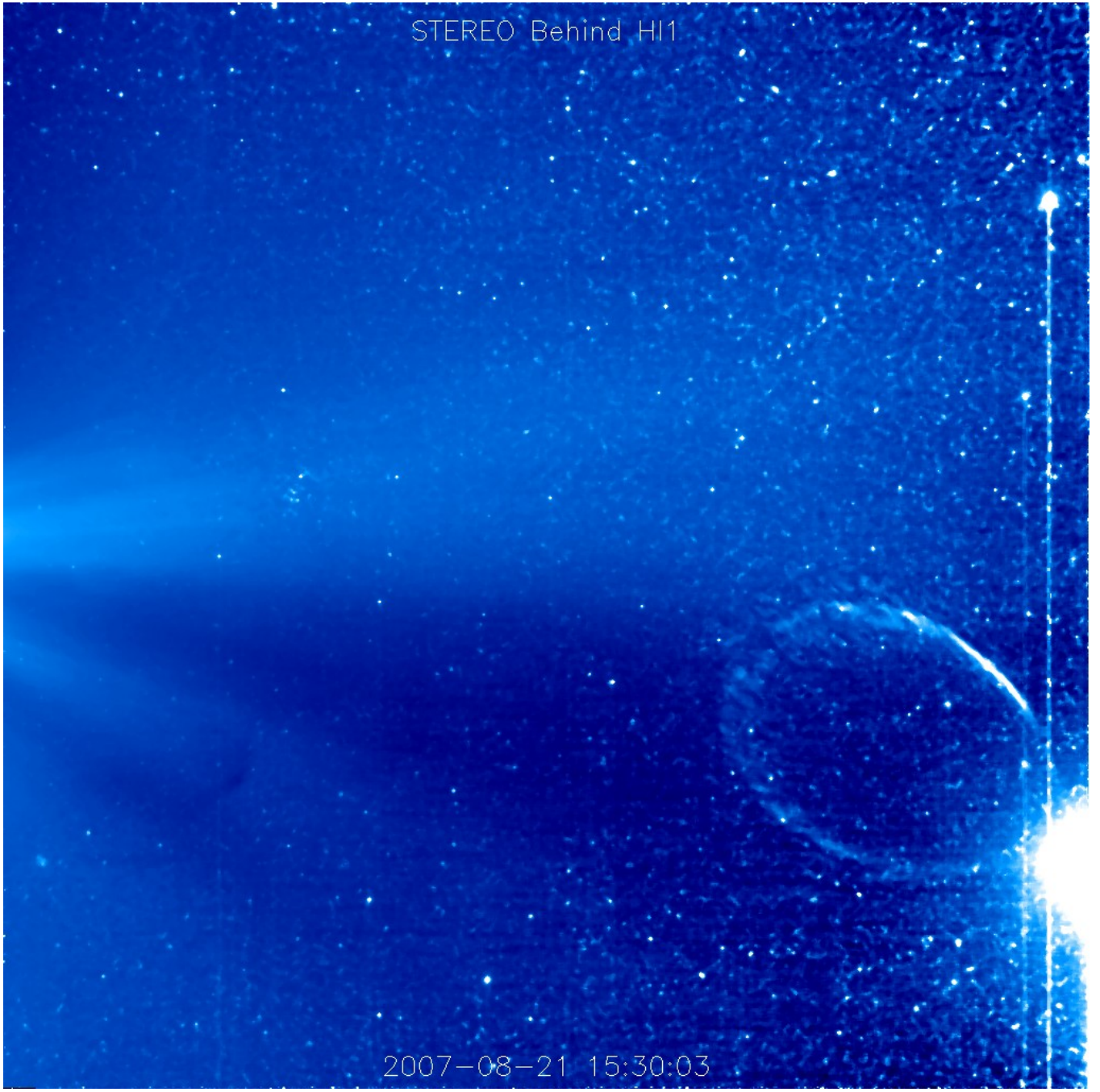
Geometric Localization



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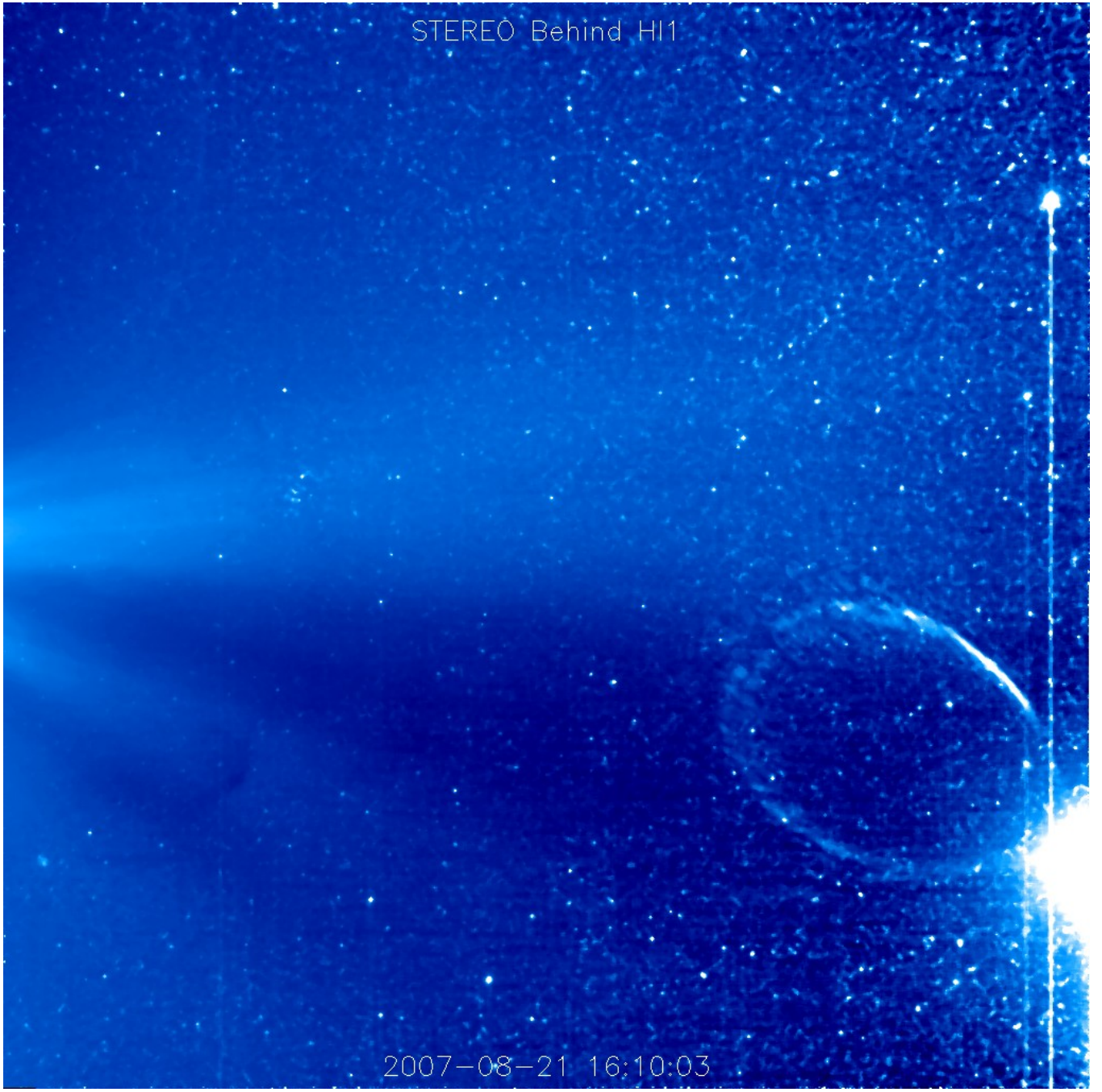
Geometric Localization



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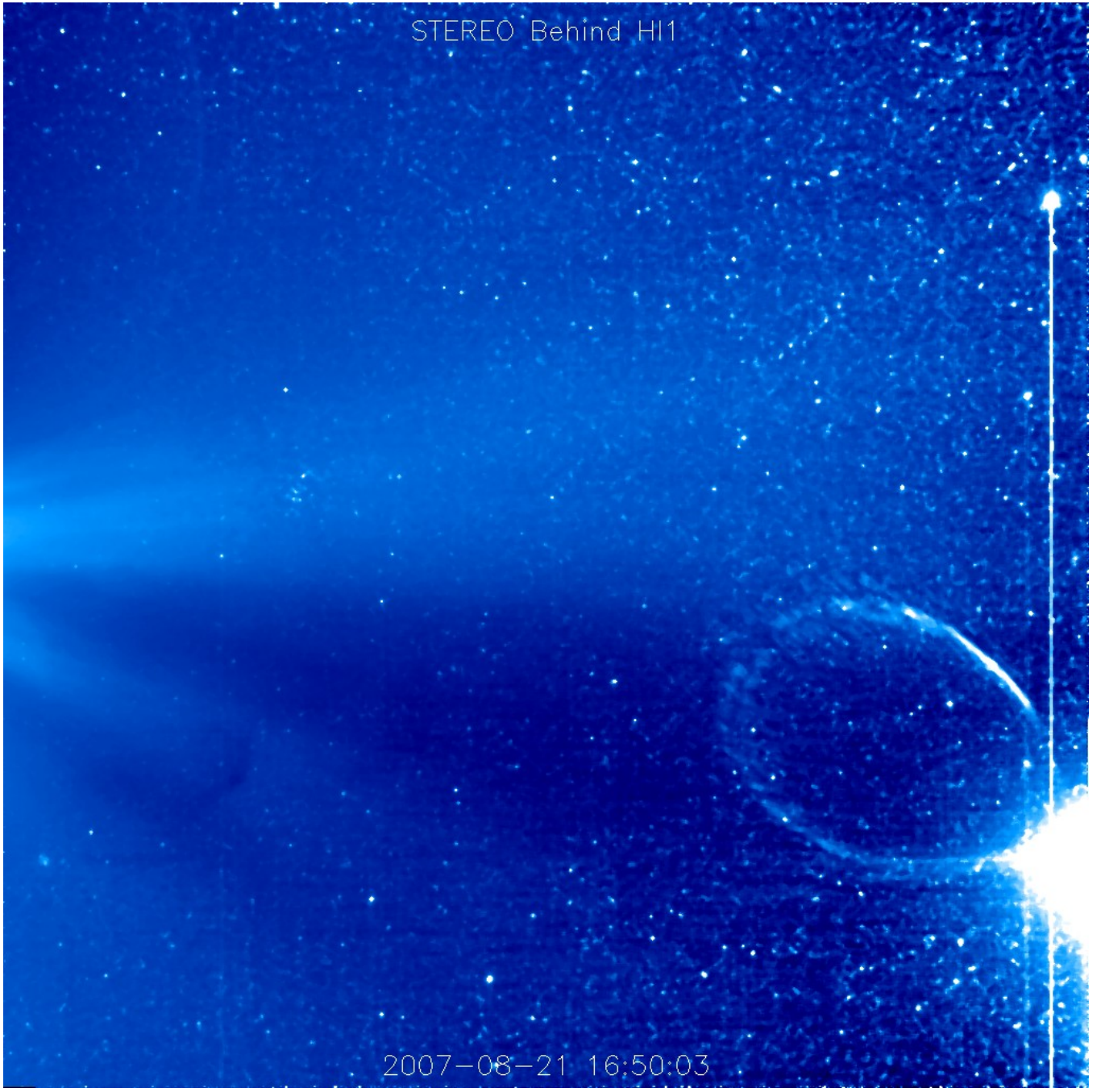
Geometric Localization



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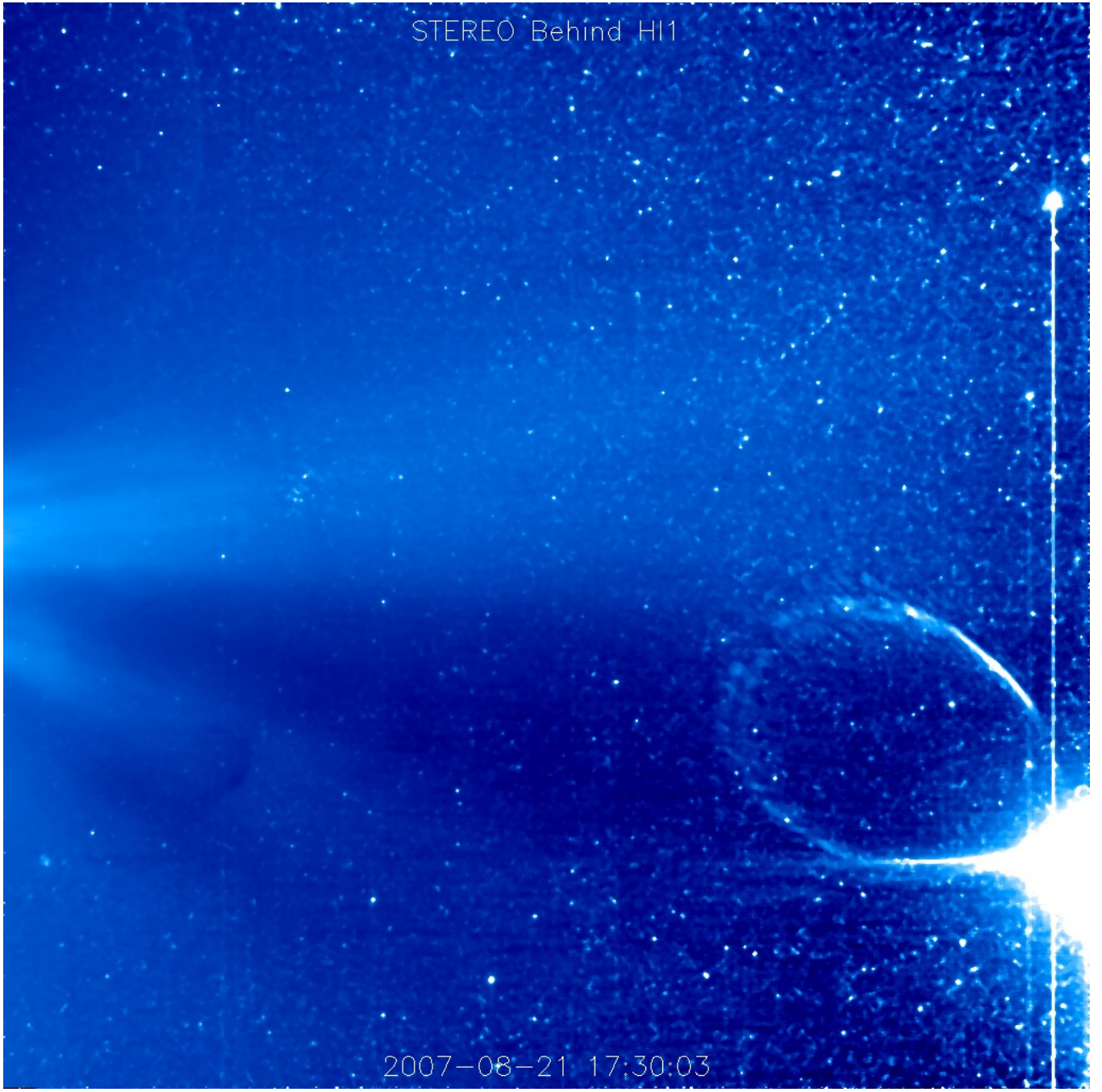
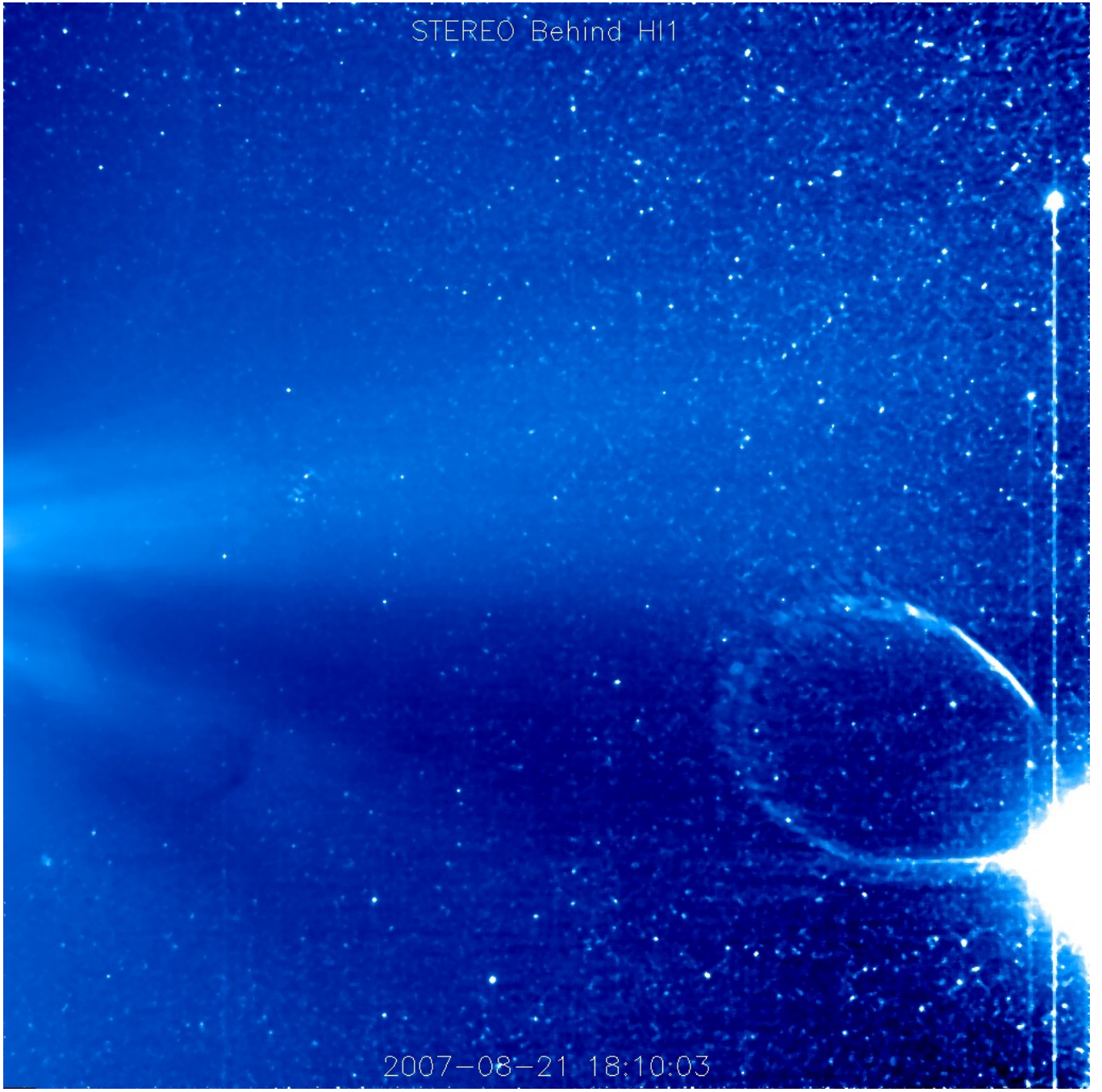


Curt A. de Koning

Geometric Localization



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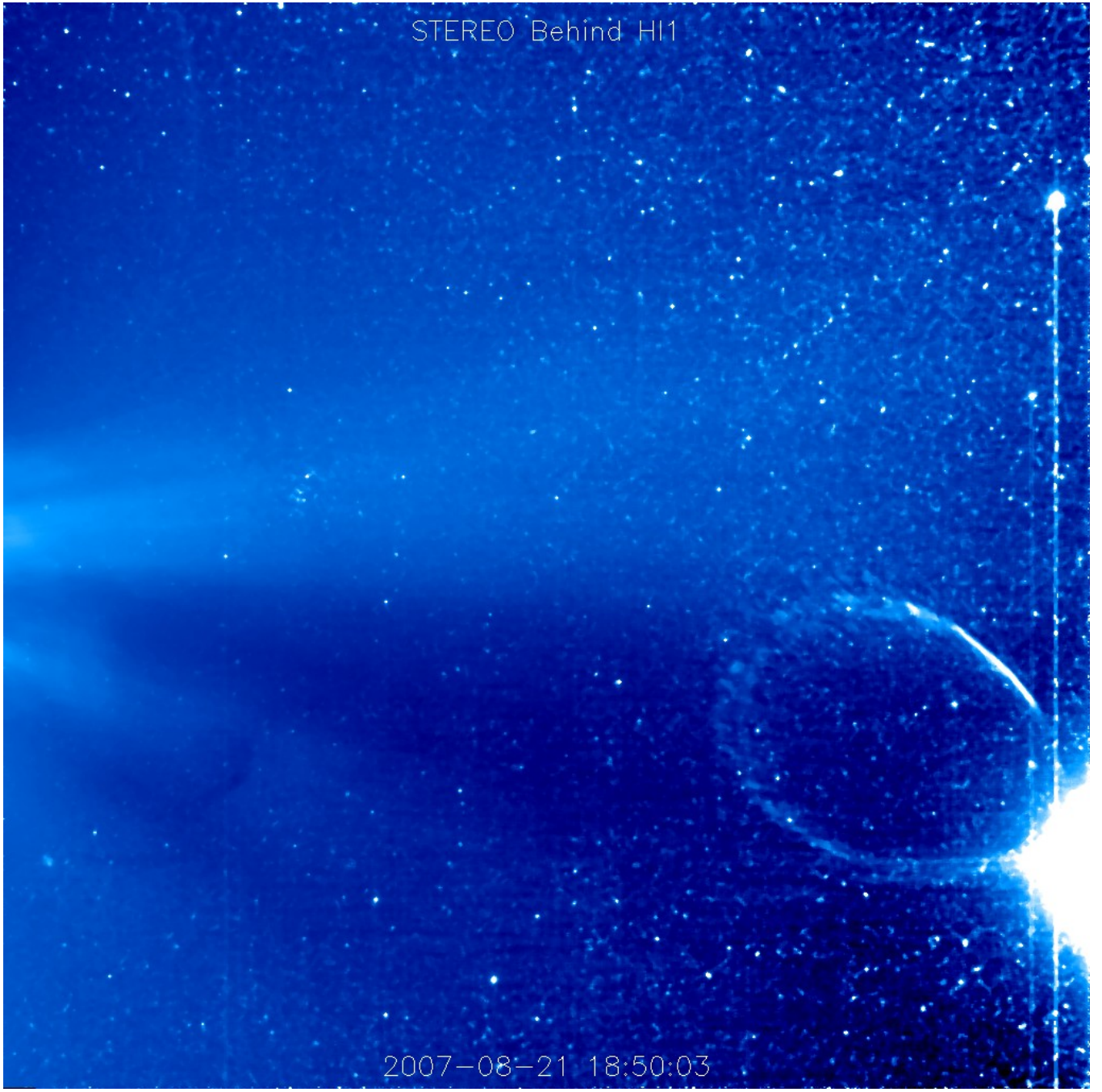
Geometric Localization



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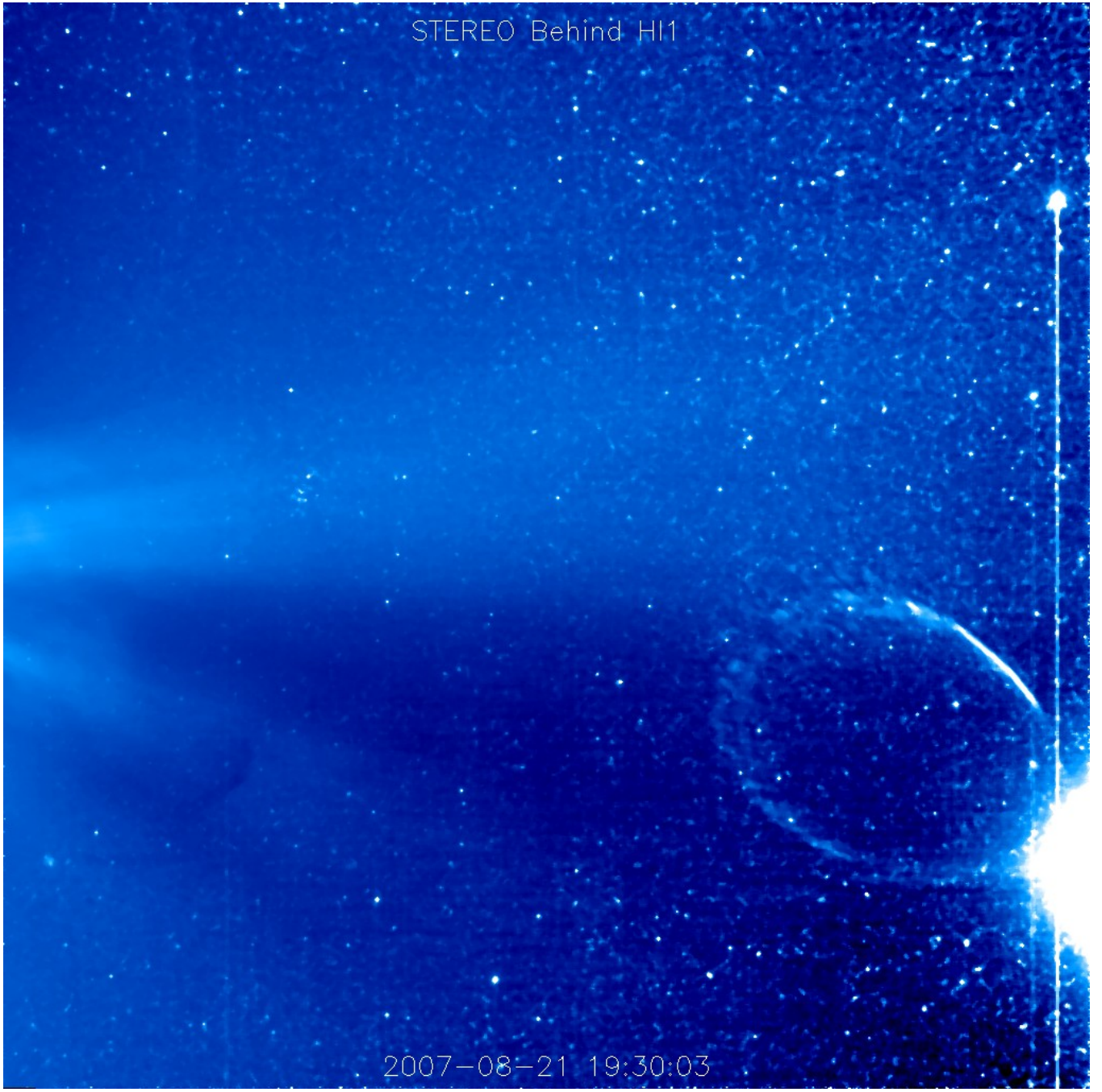

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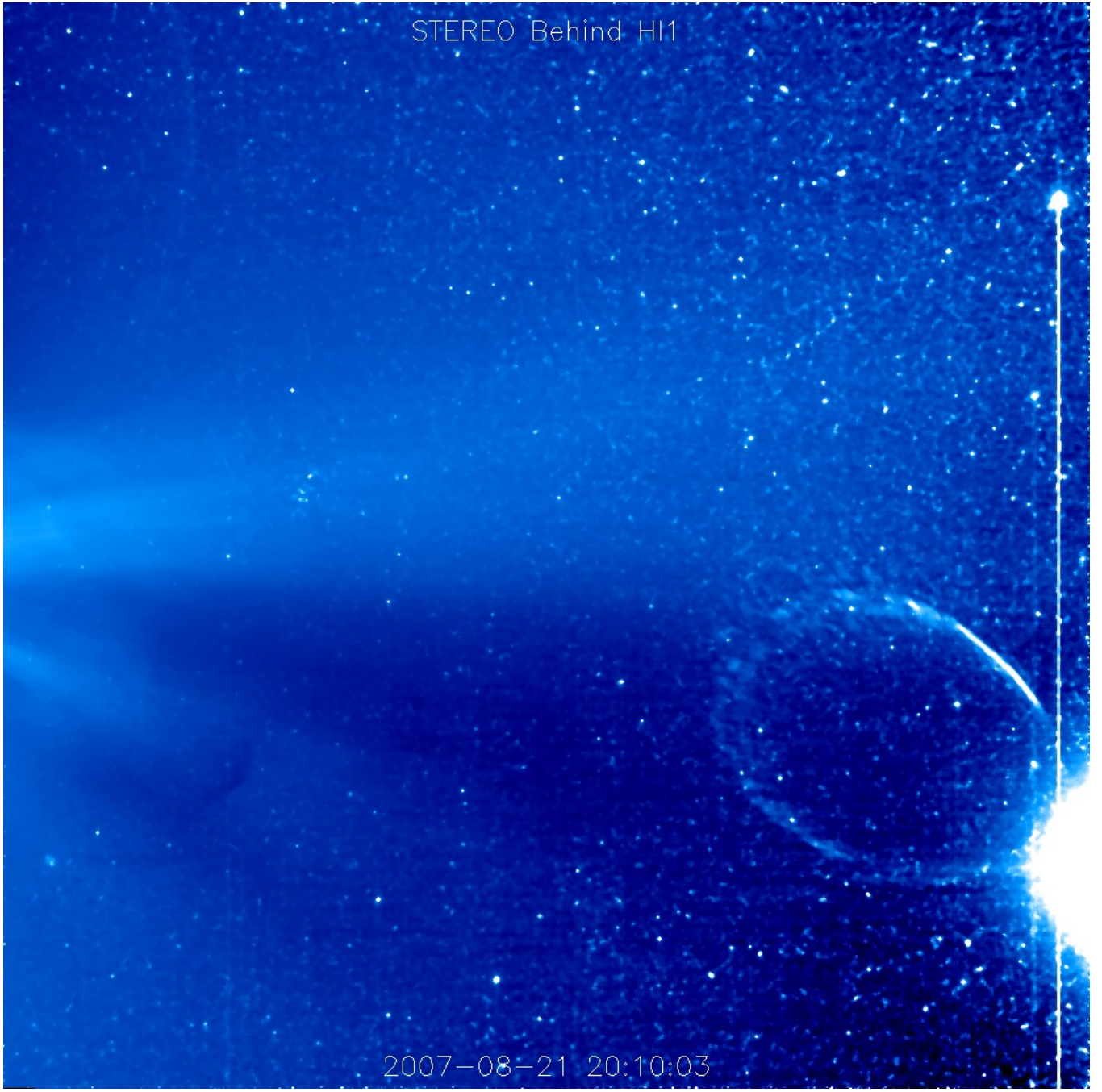
Geometric Localization



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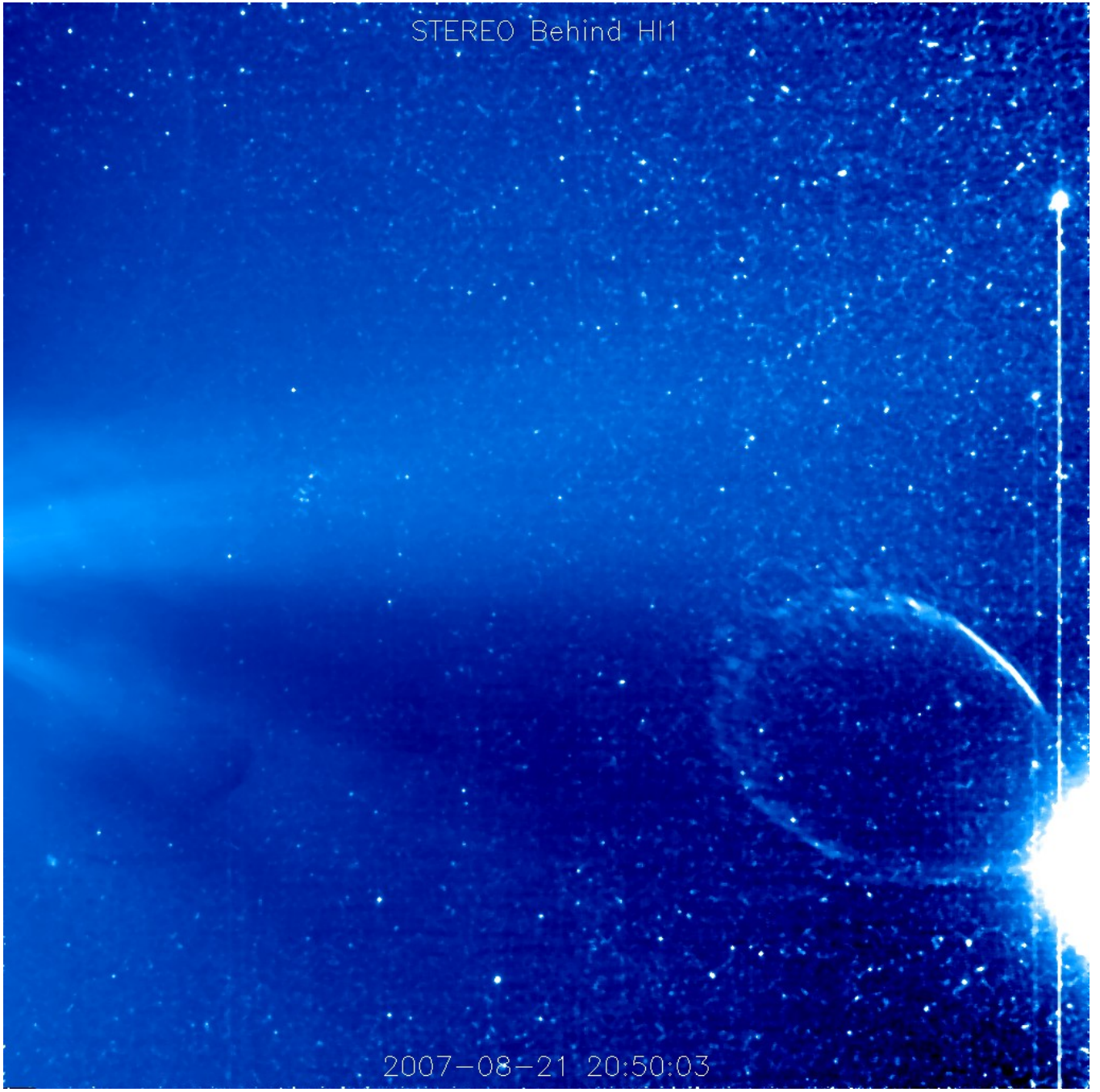
Geometric Localization



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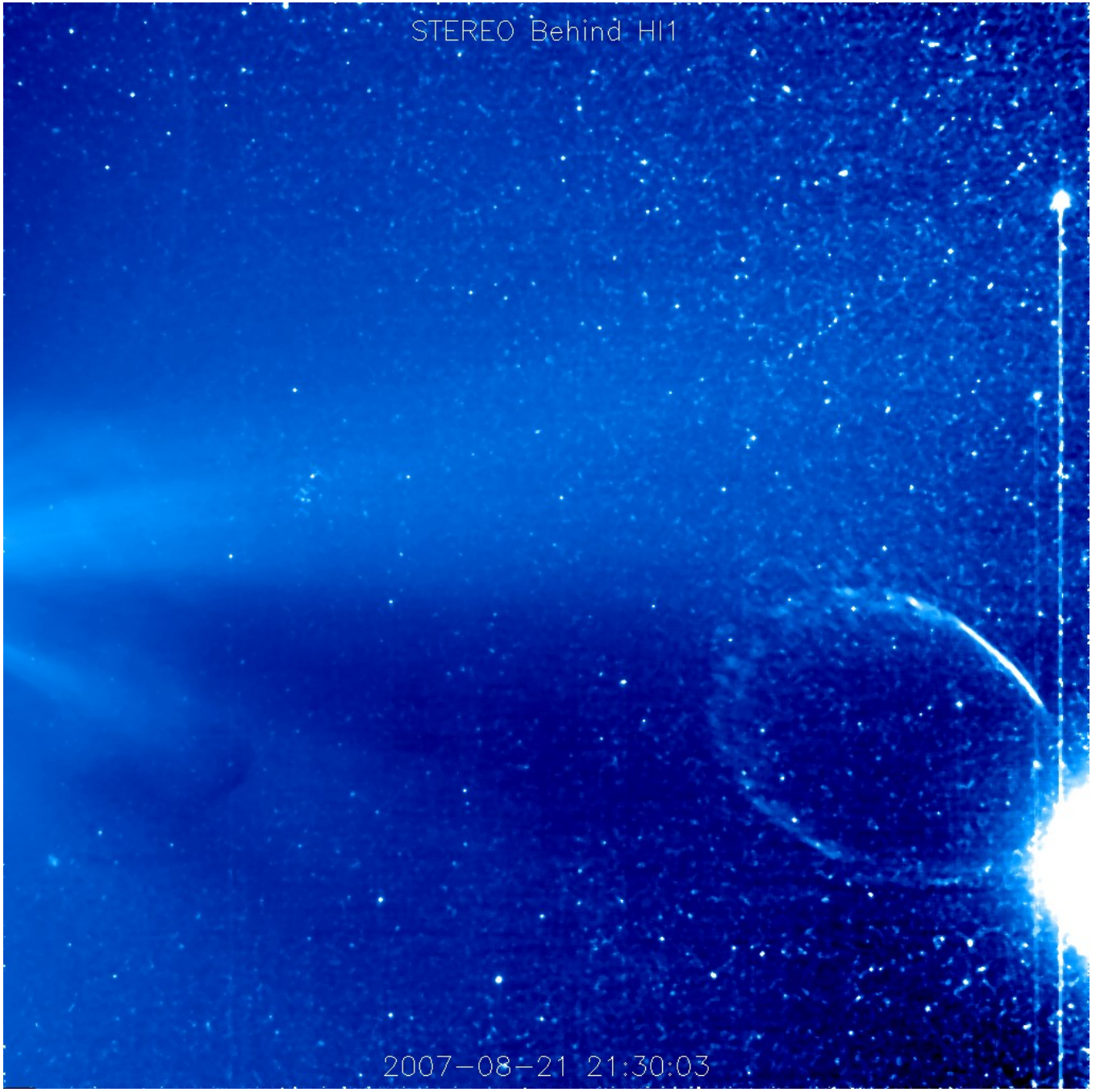

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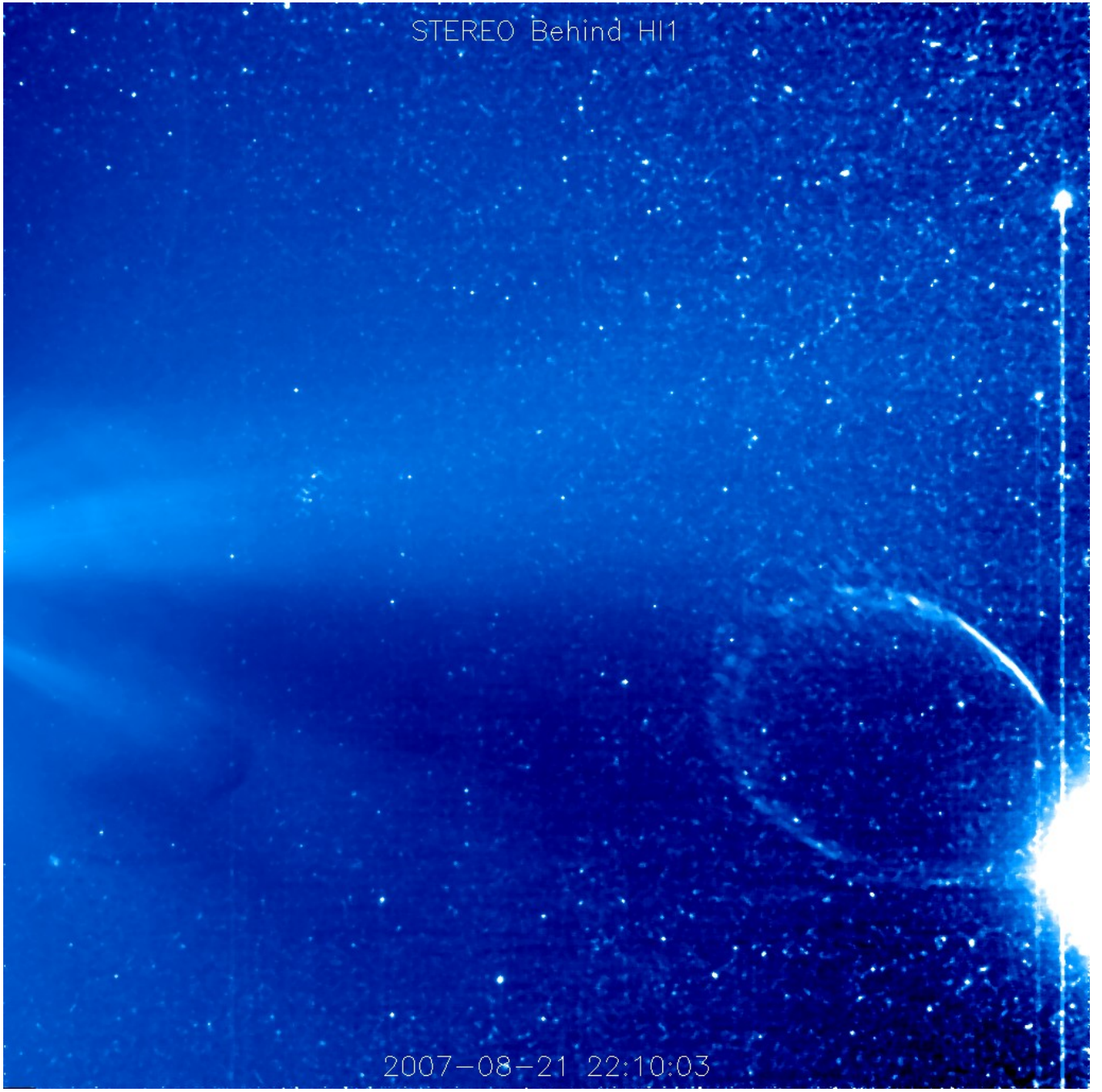
Geometric Localization



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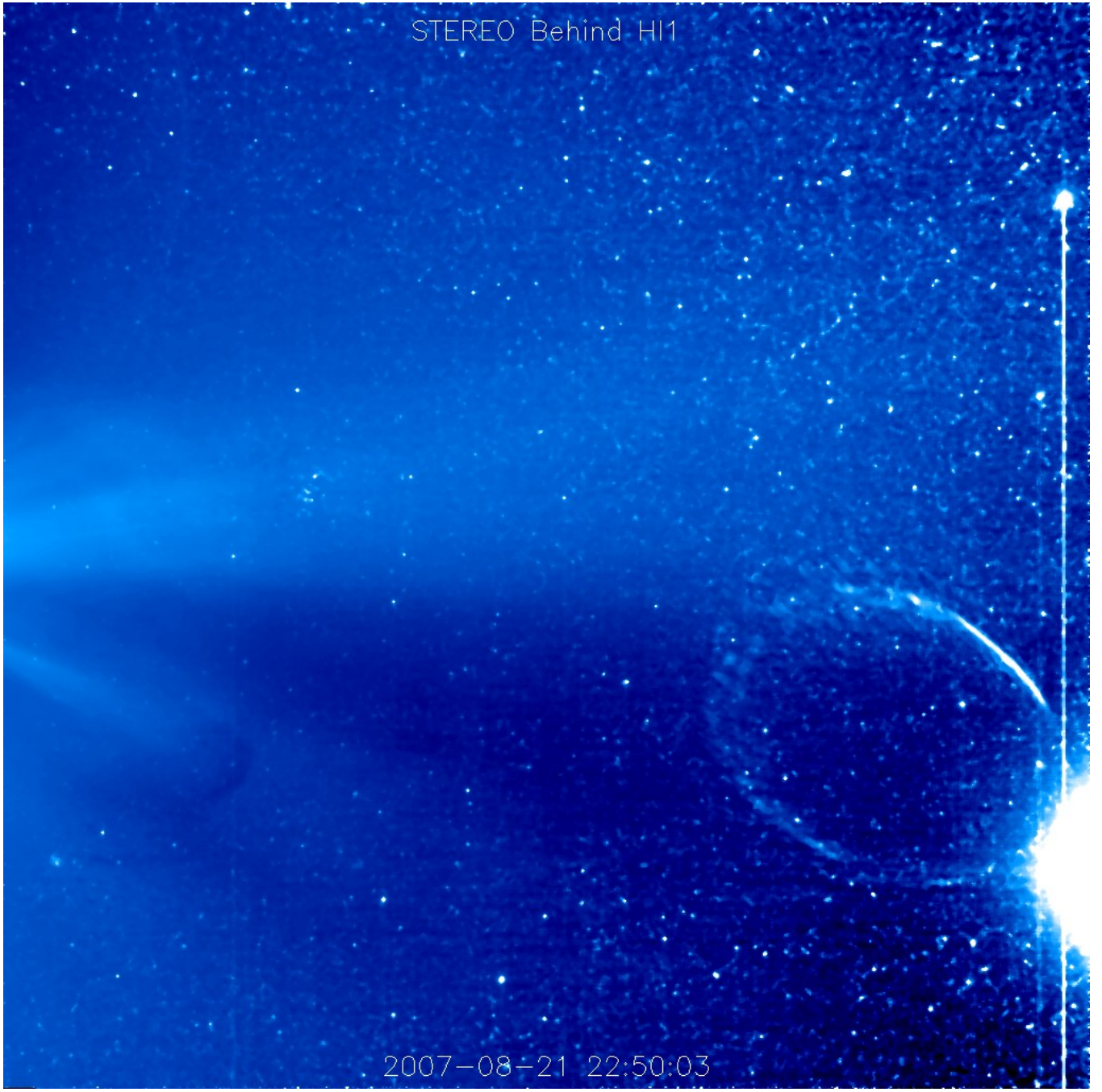

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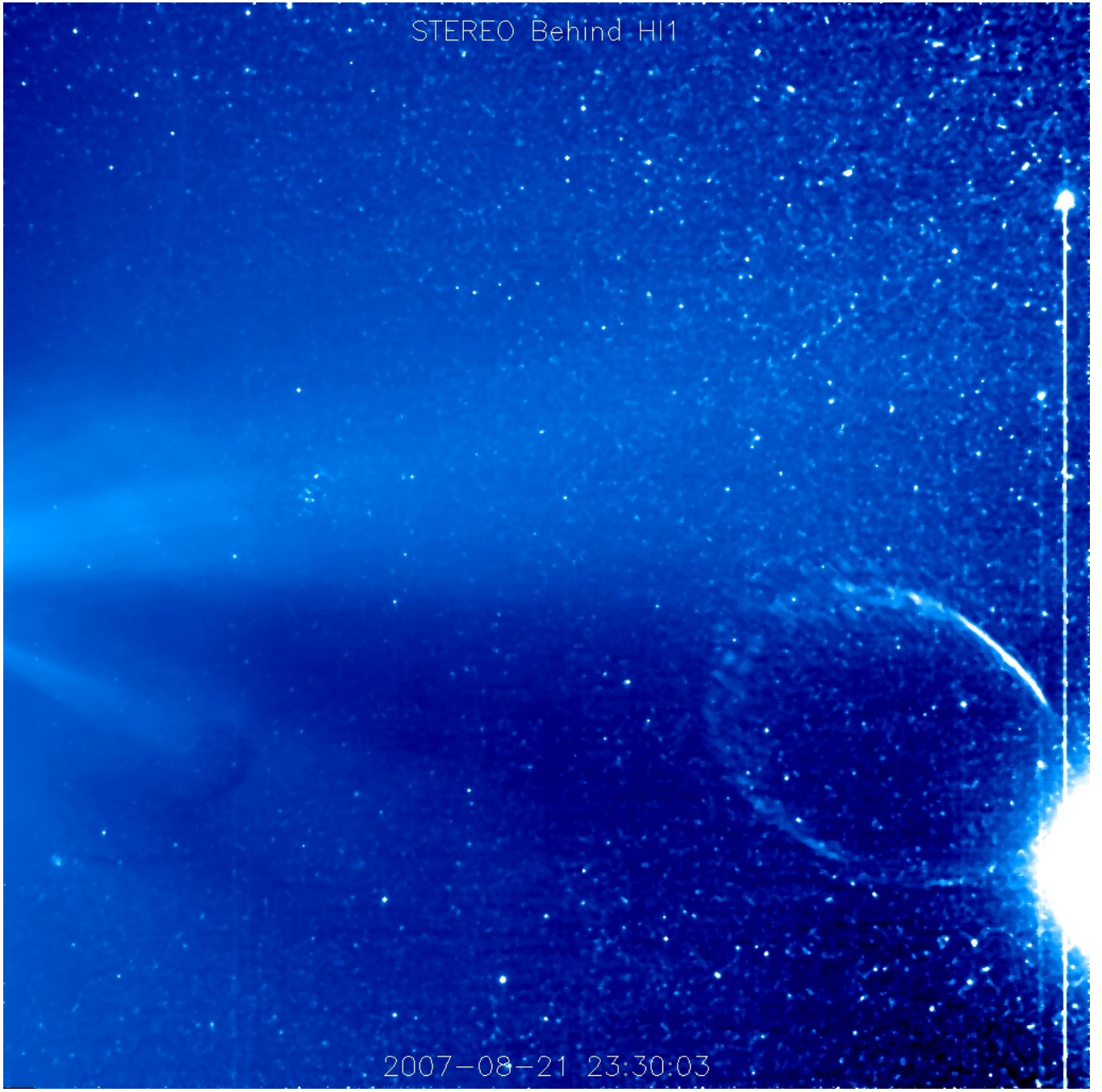

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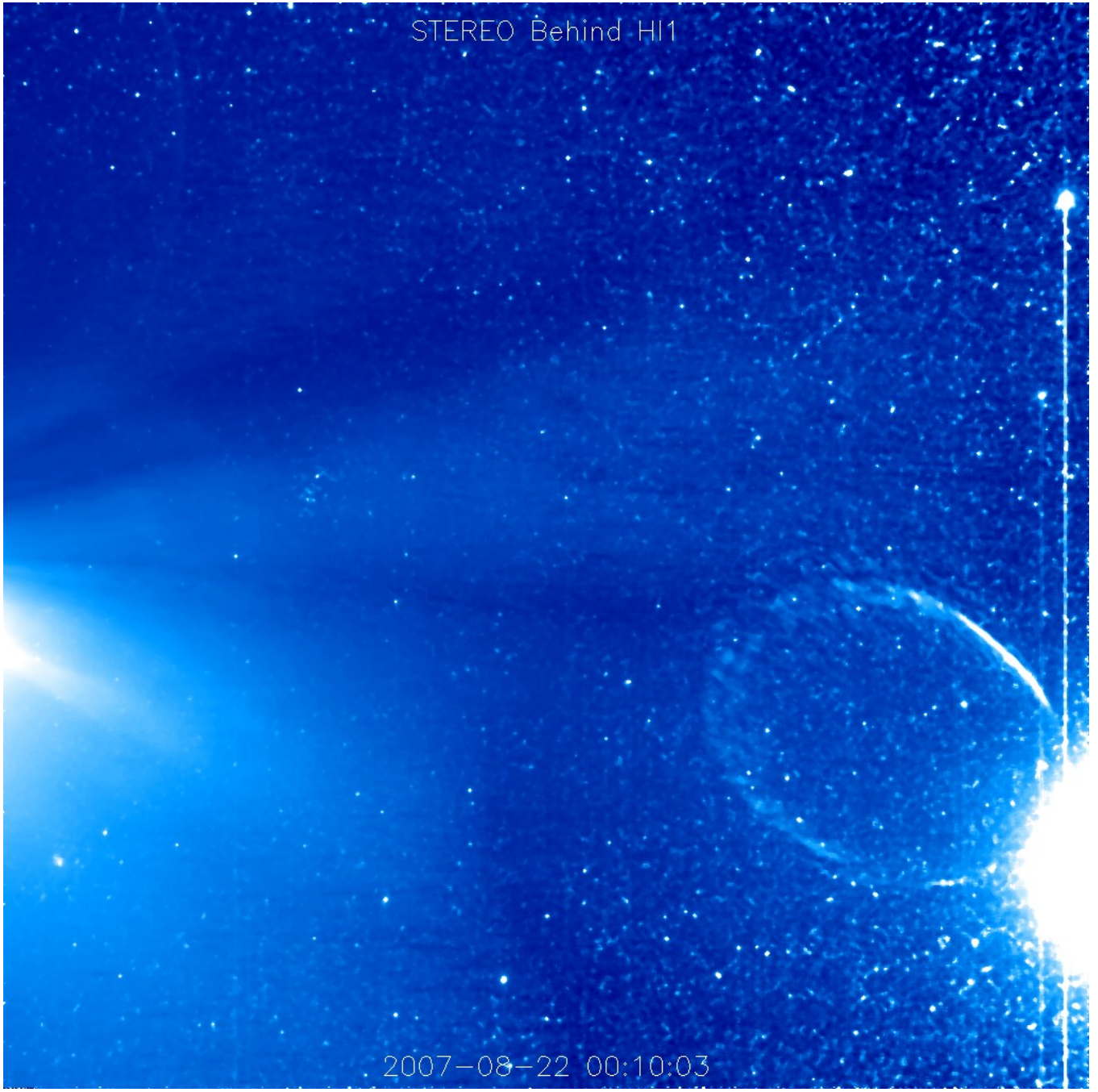

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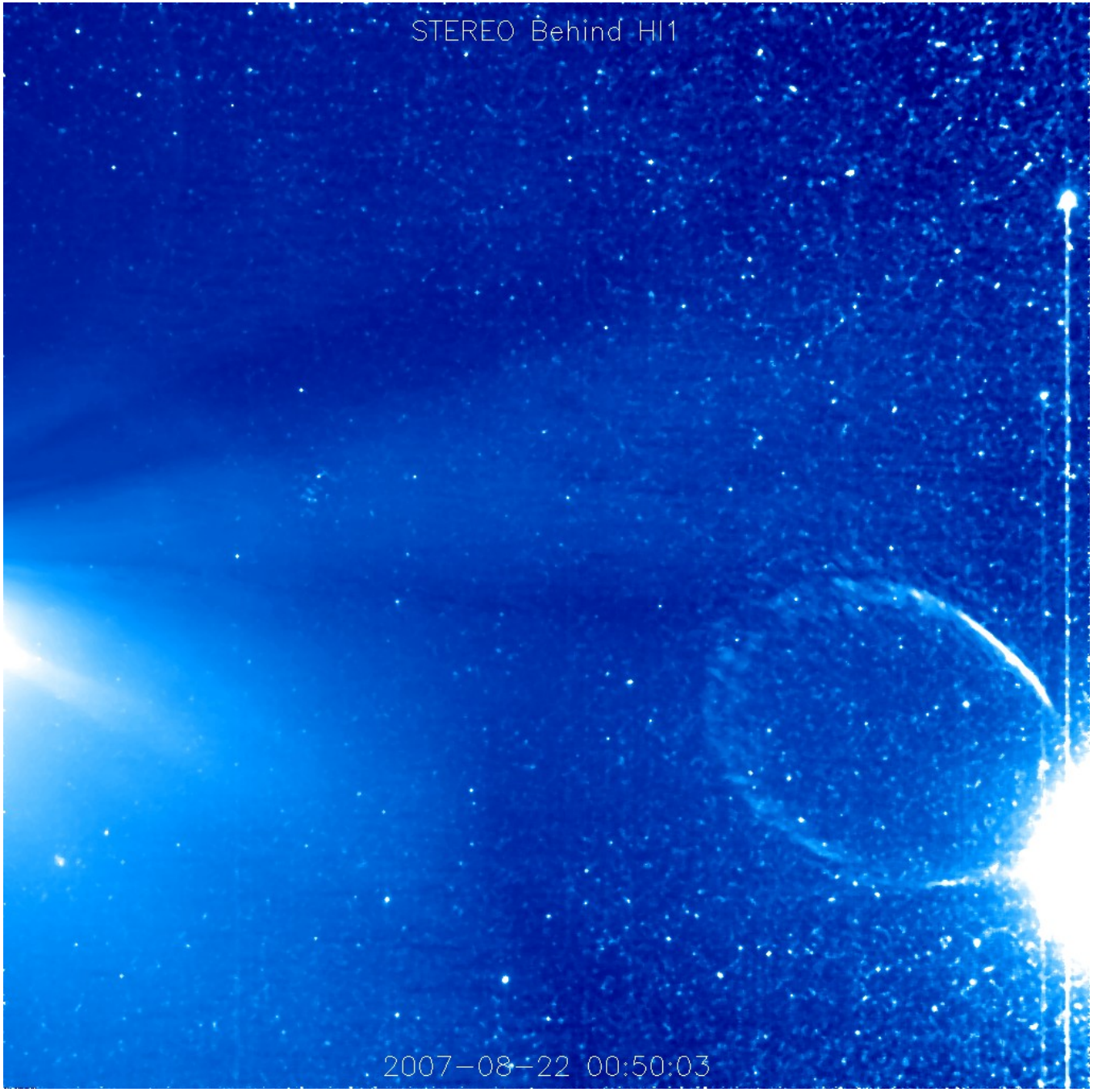

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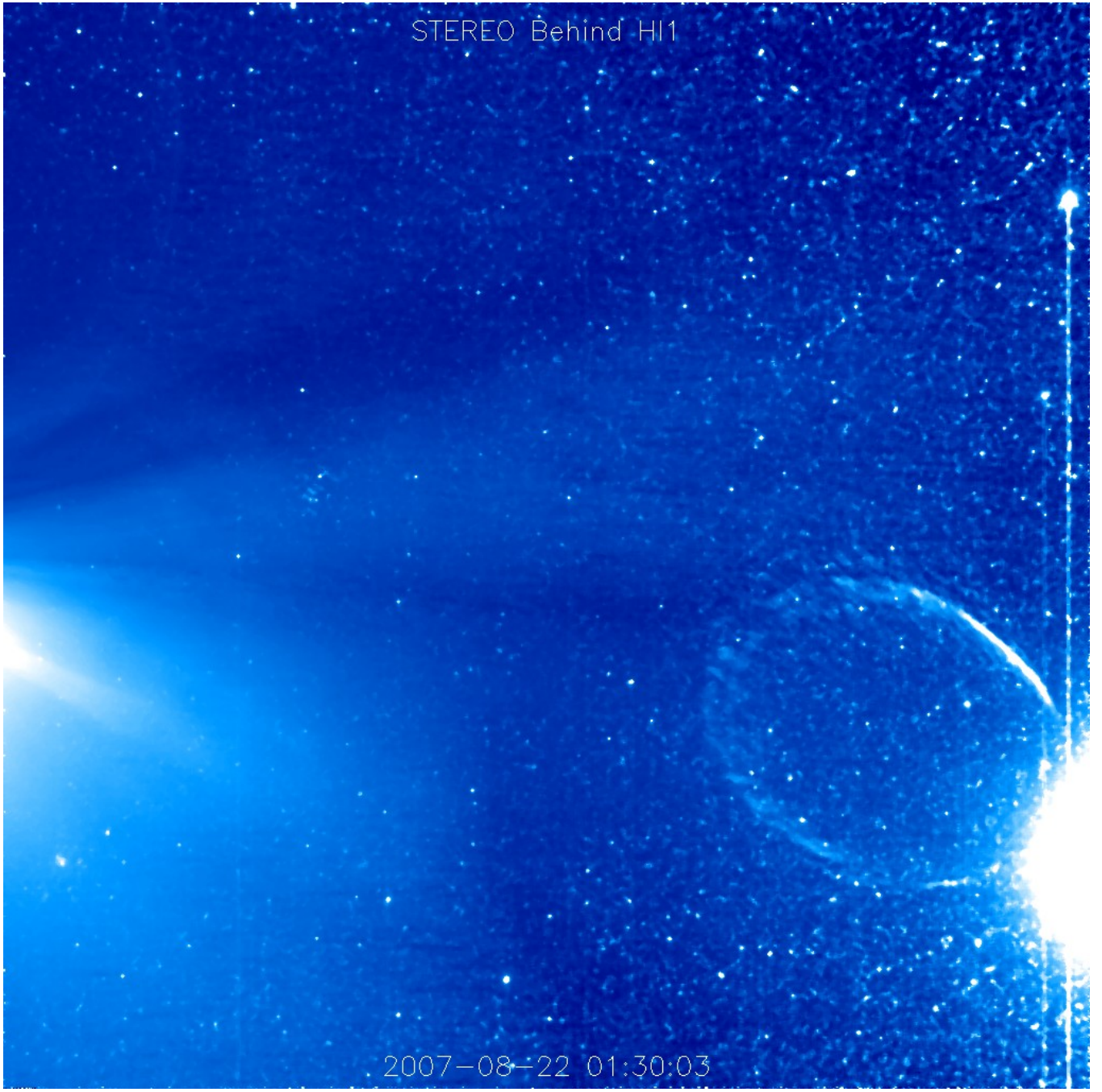

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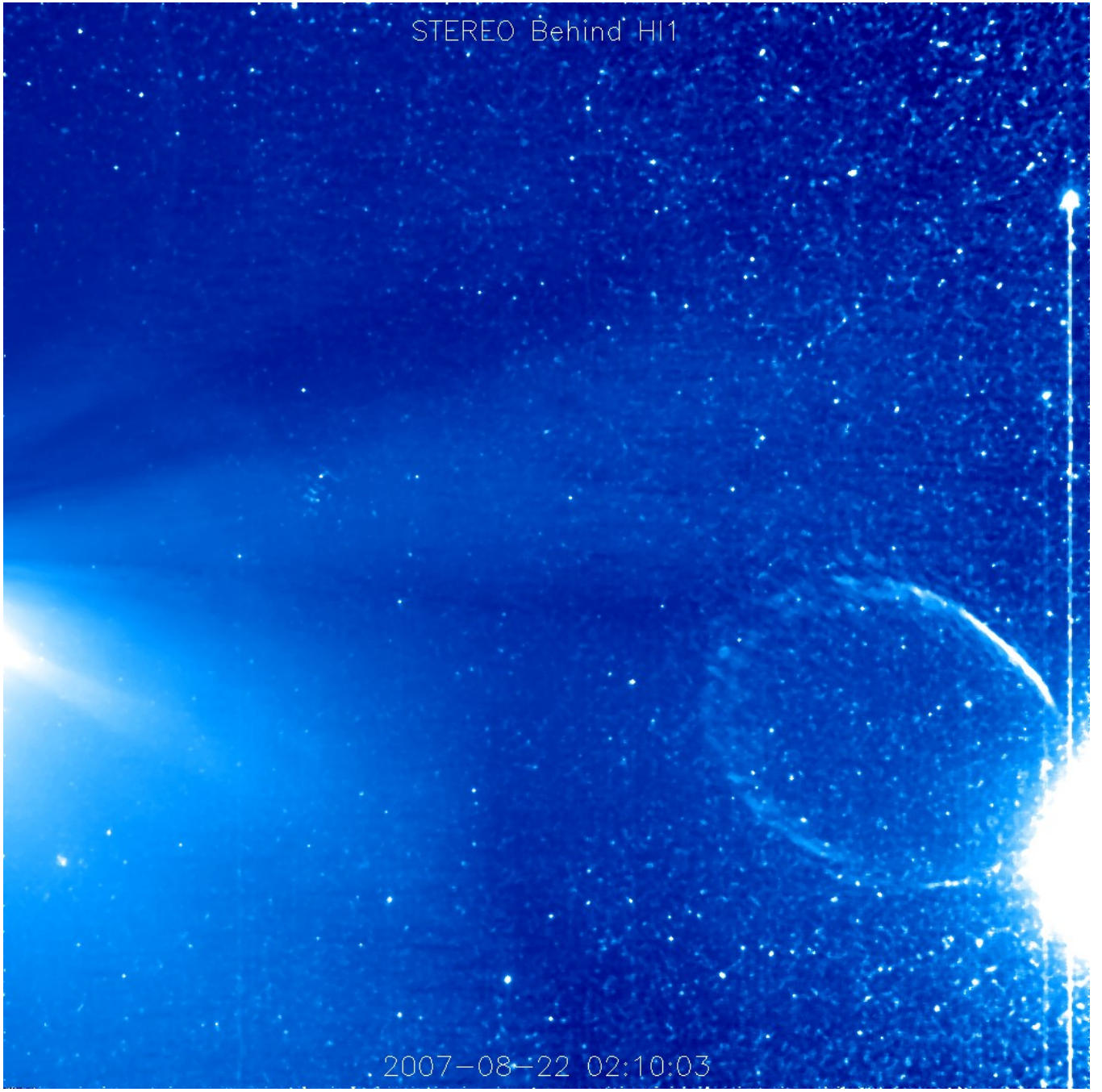

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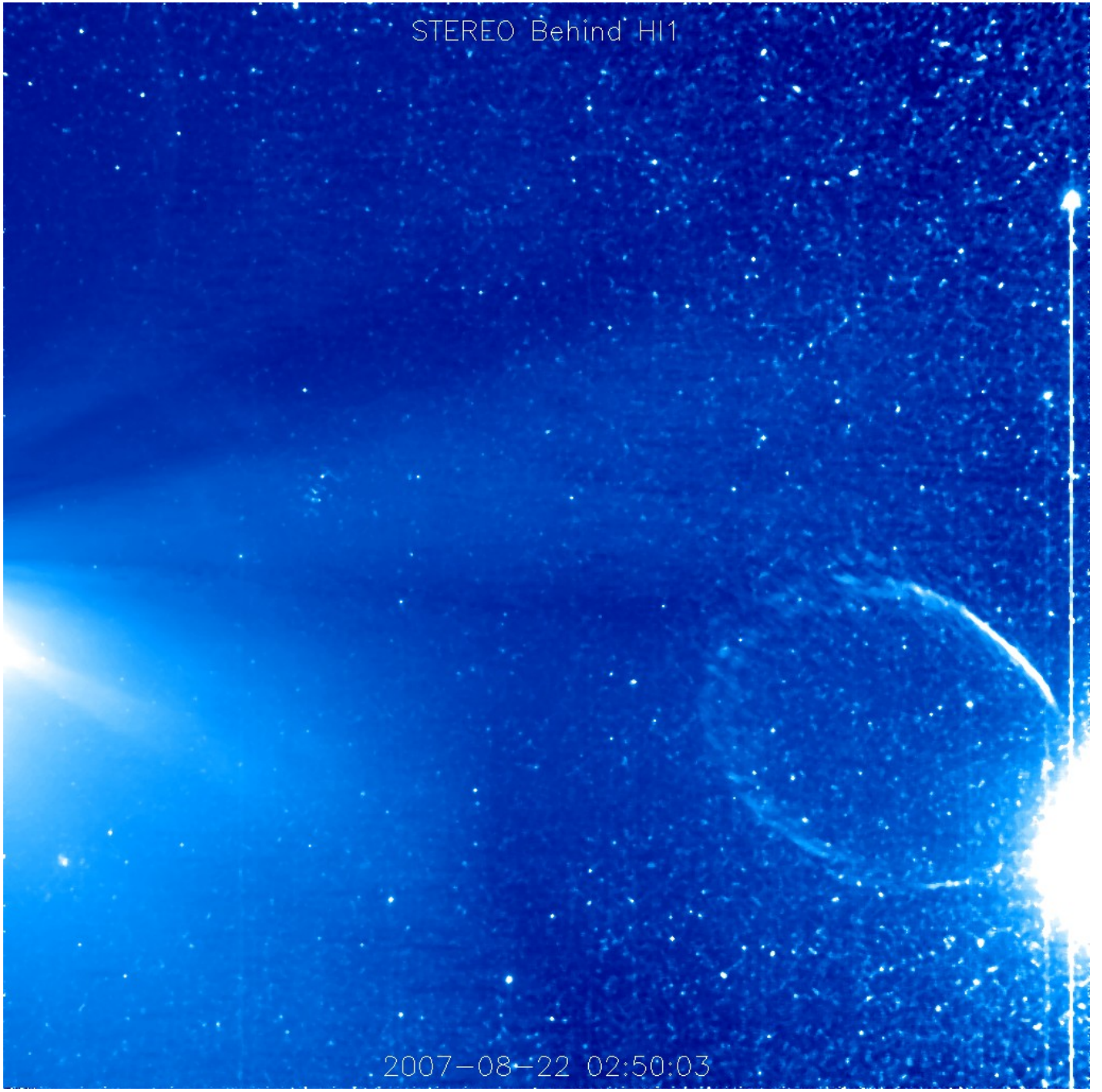

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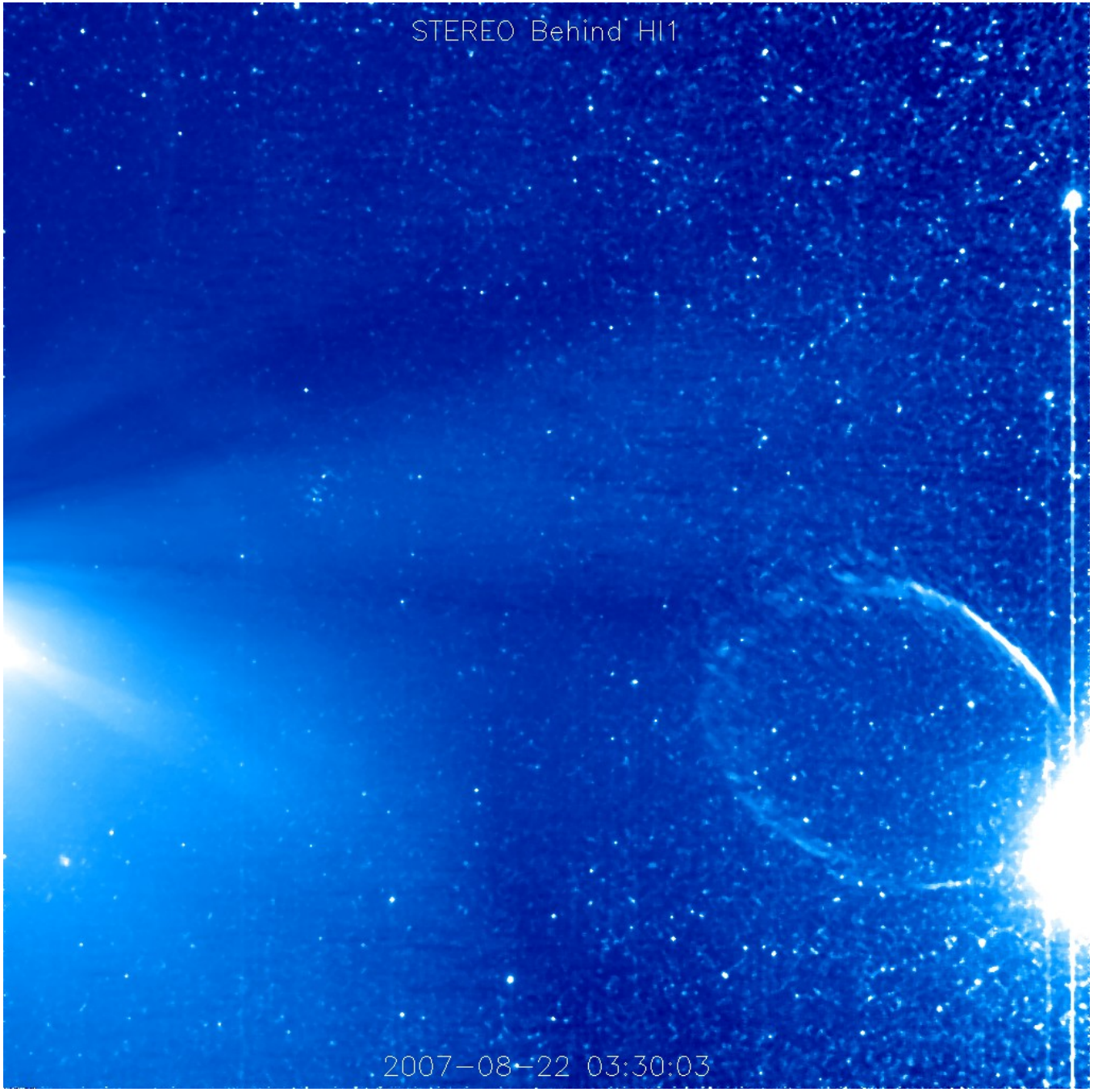

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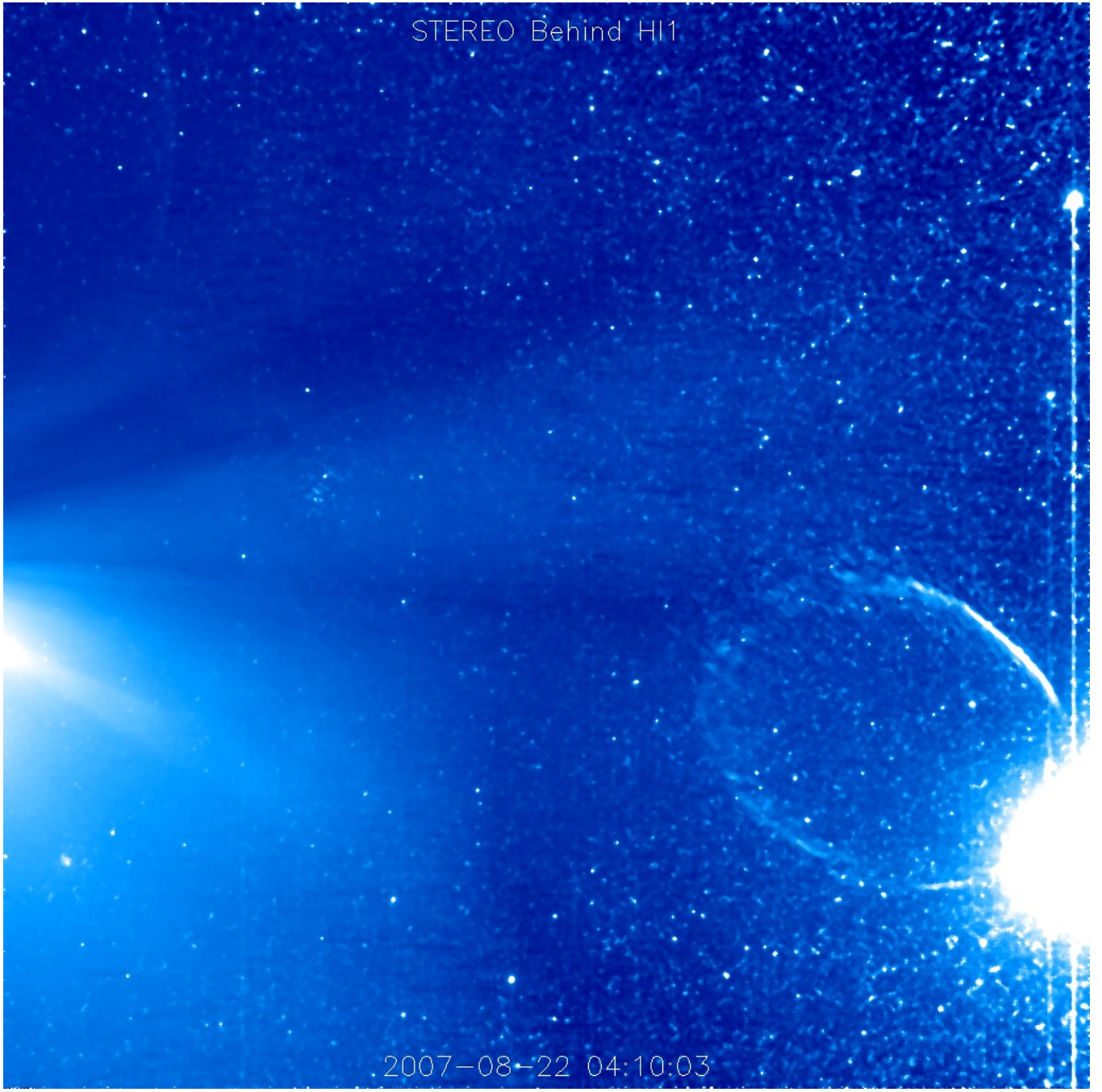

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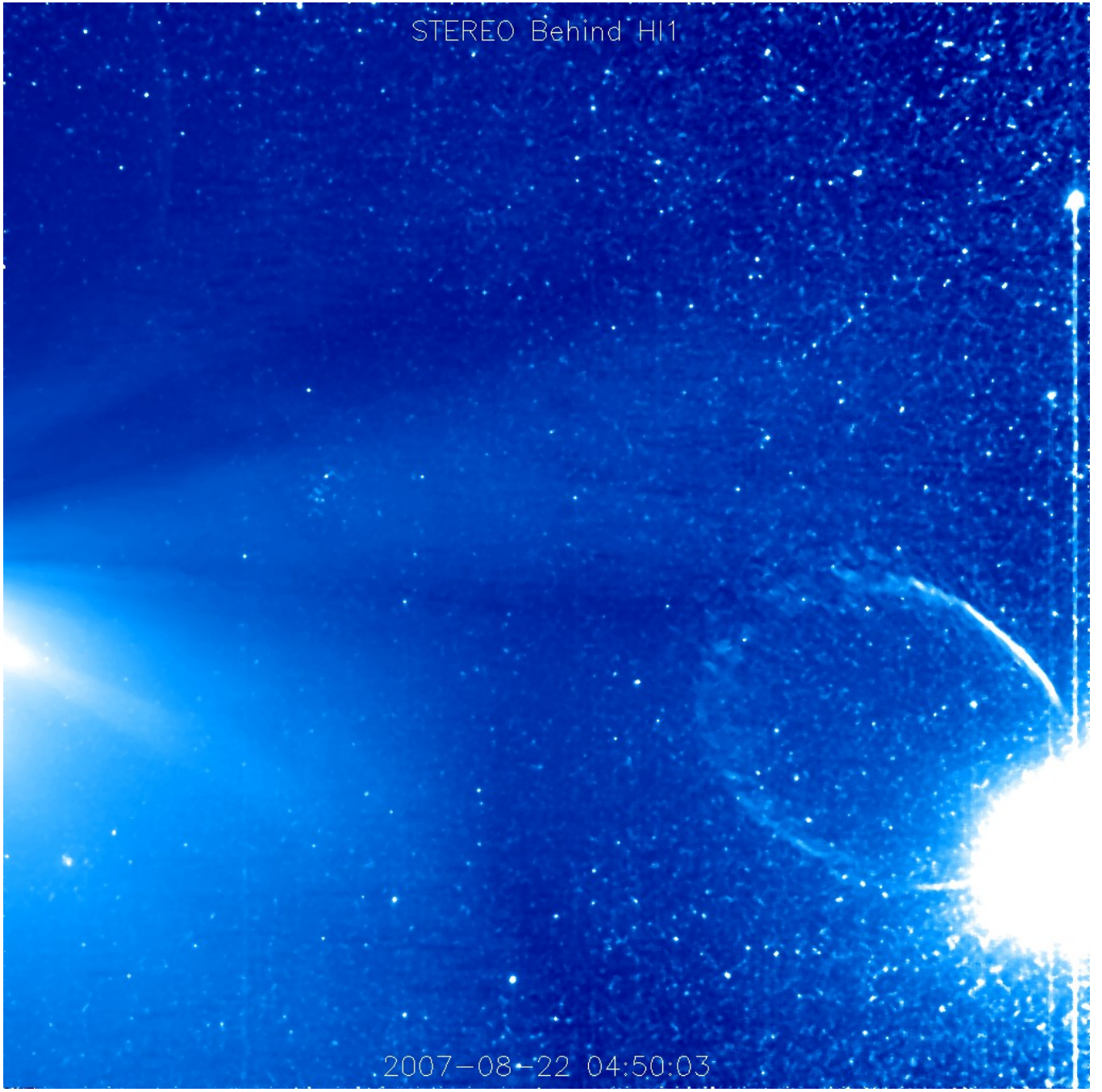

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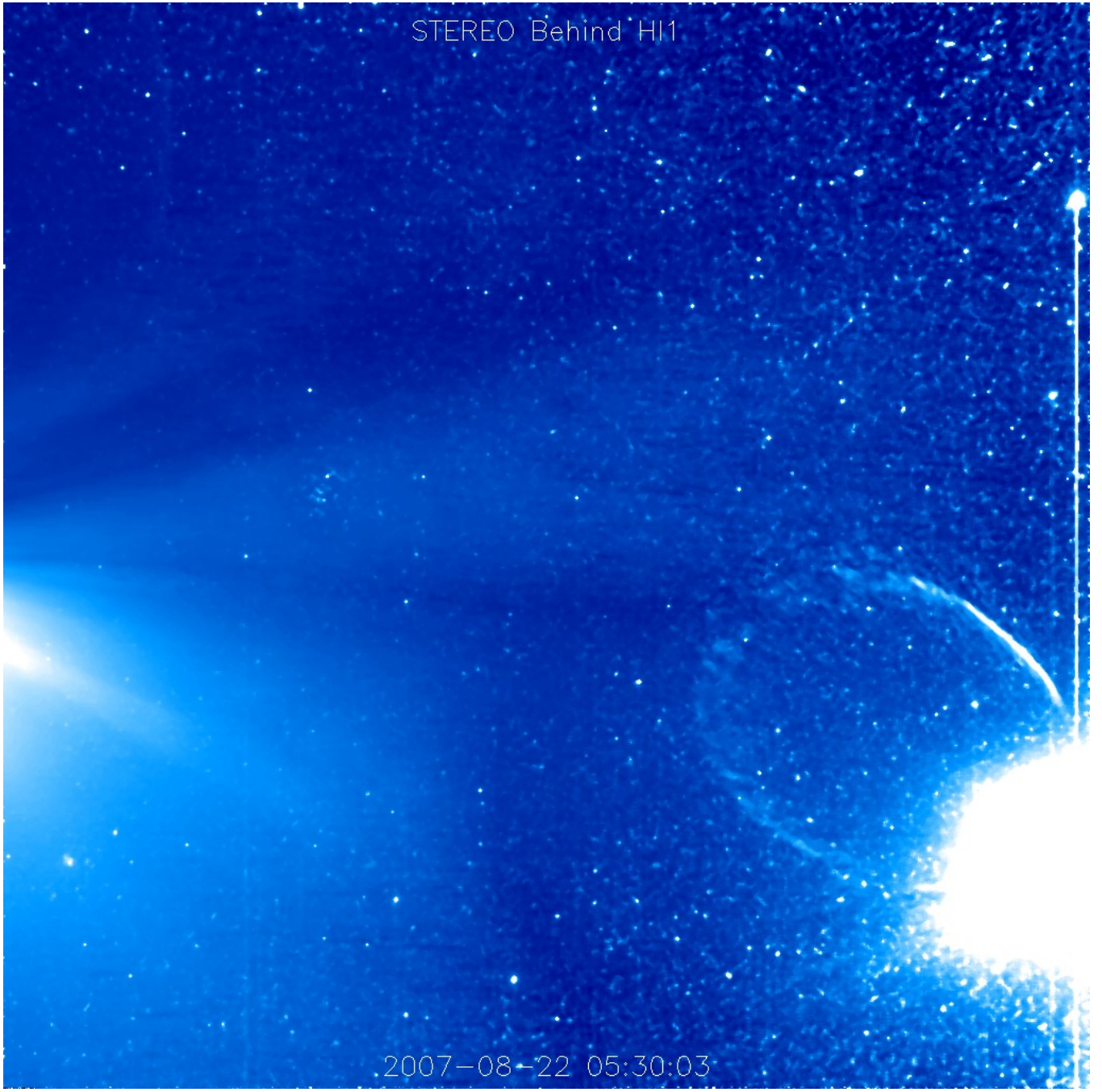

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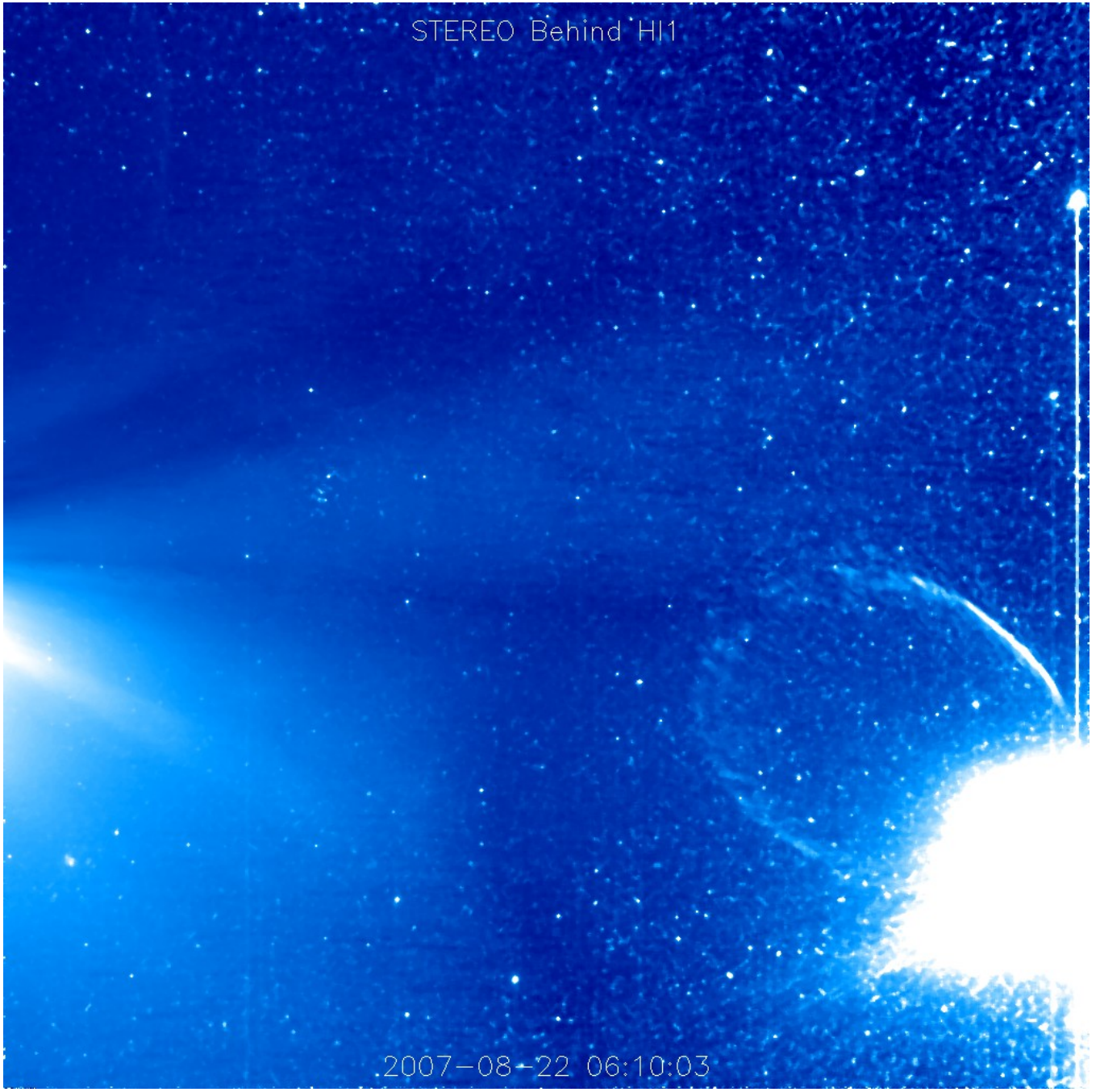

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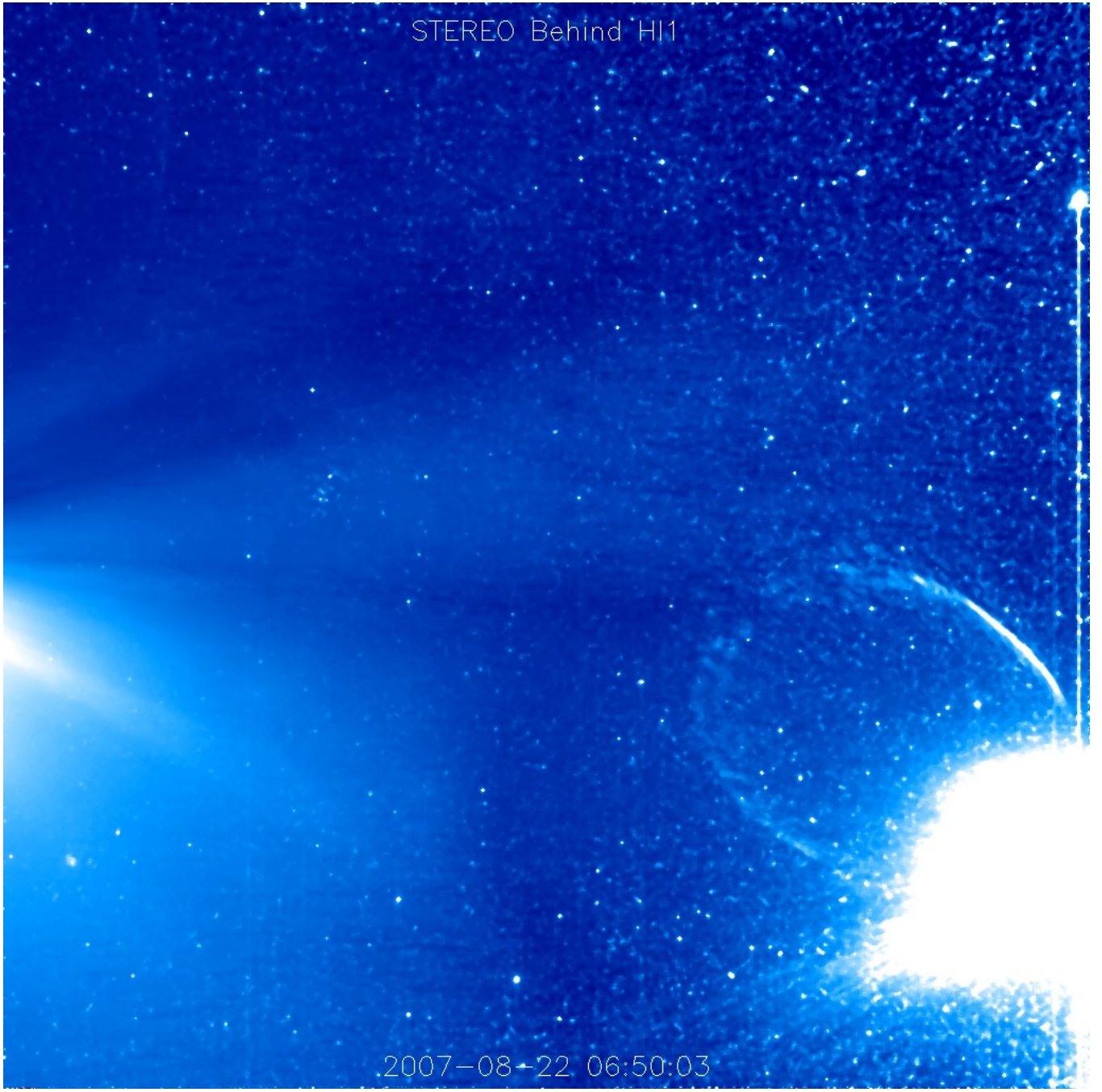

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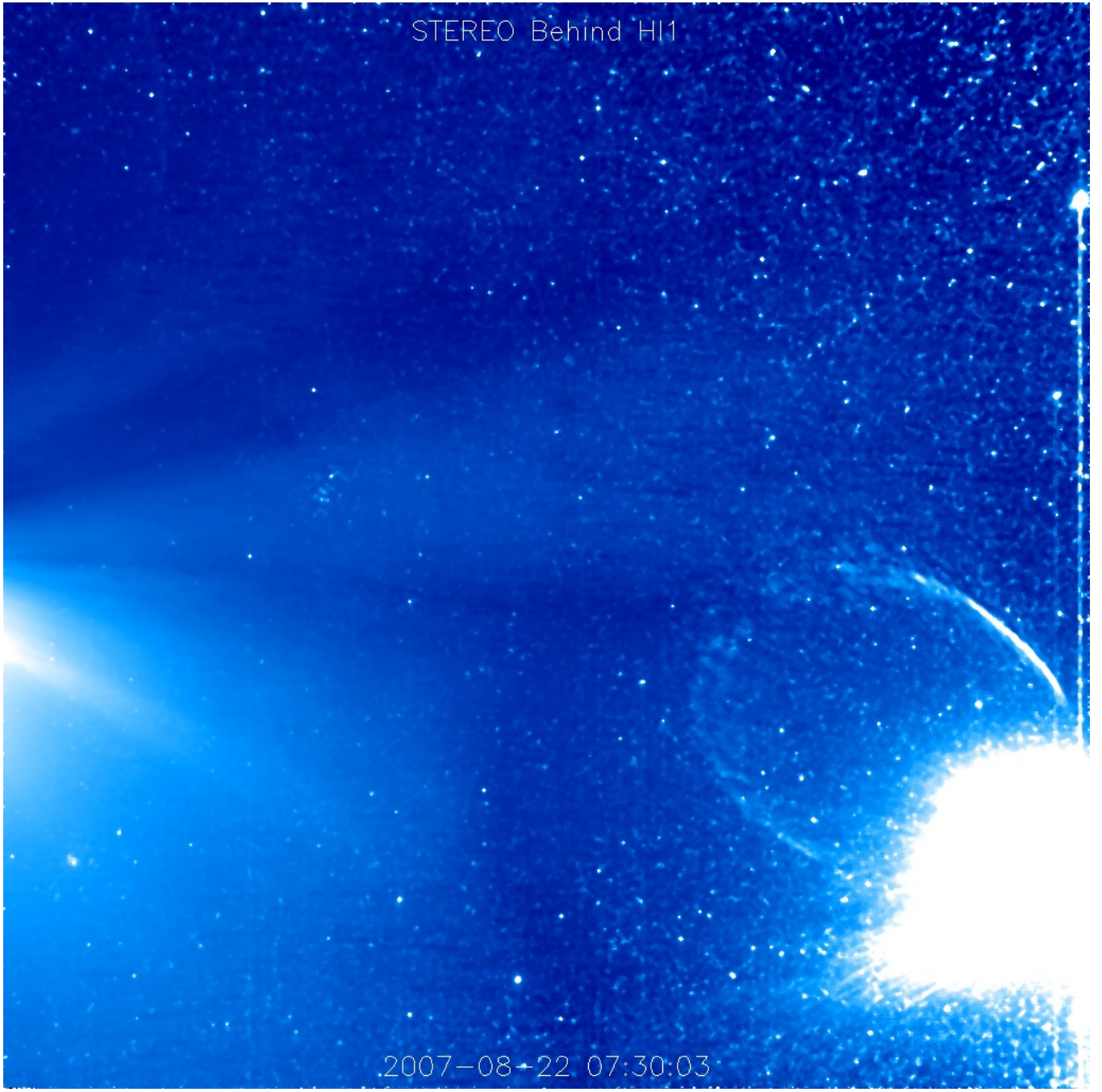
Geometric Localization



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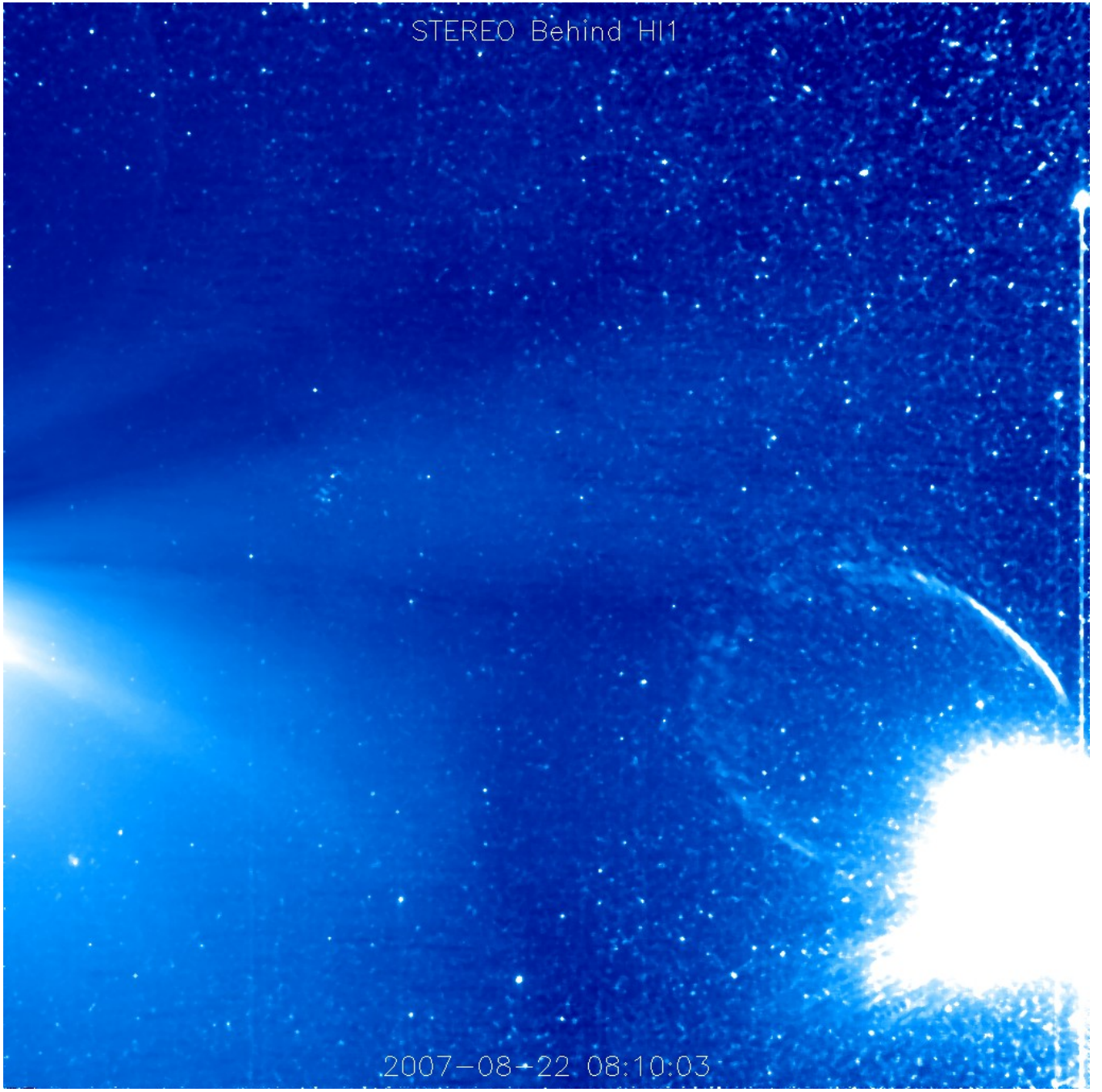
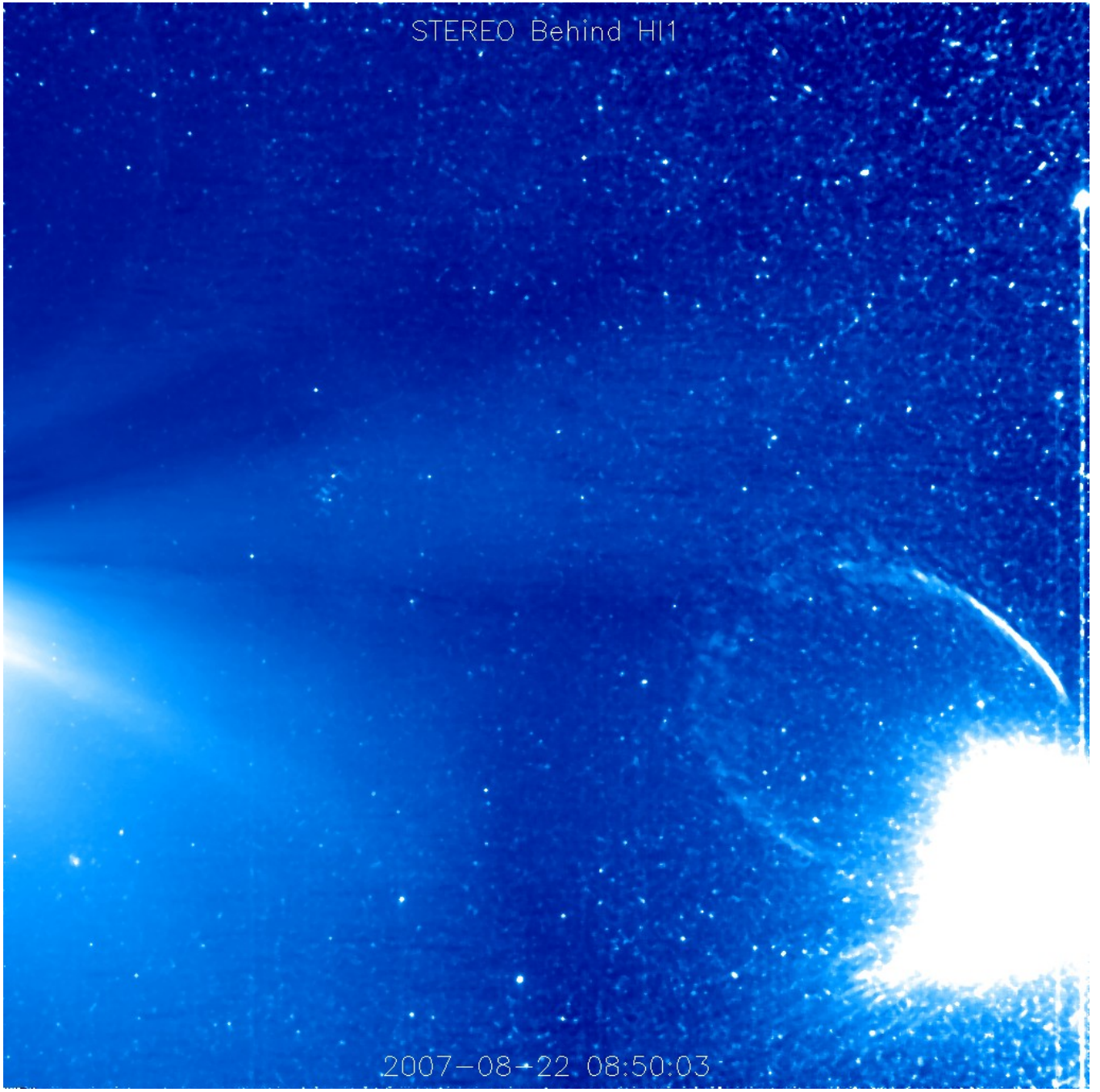
Geometric Localization



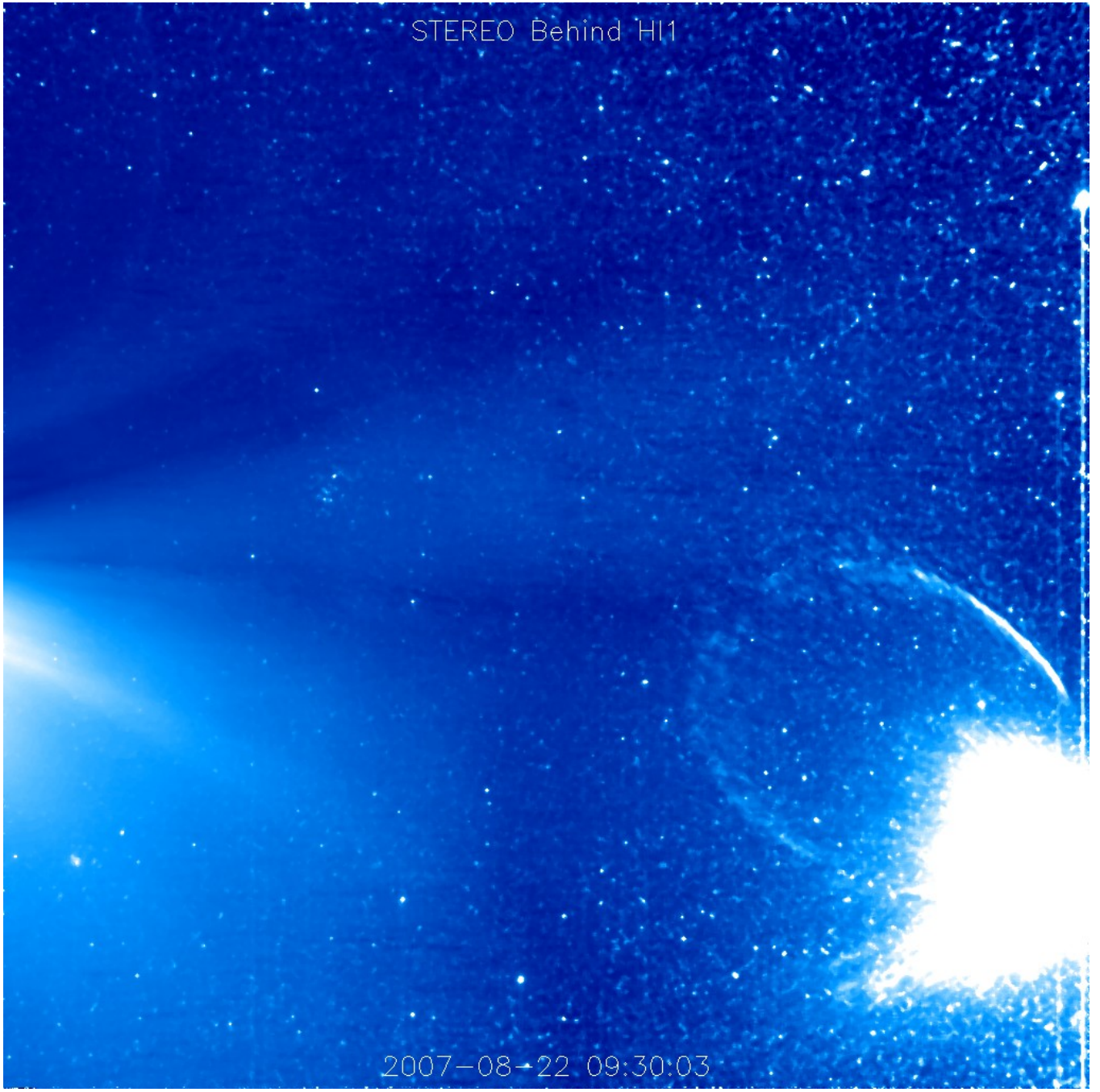
Curt A. de Koning

Geometric Localization



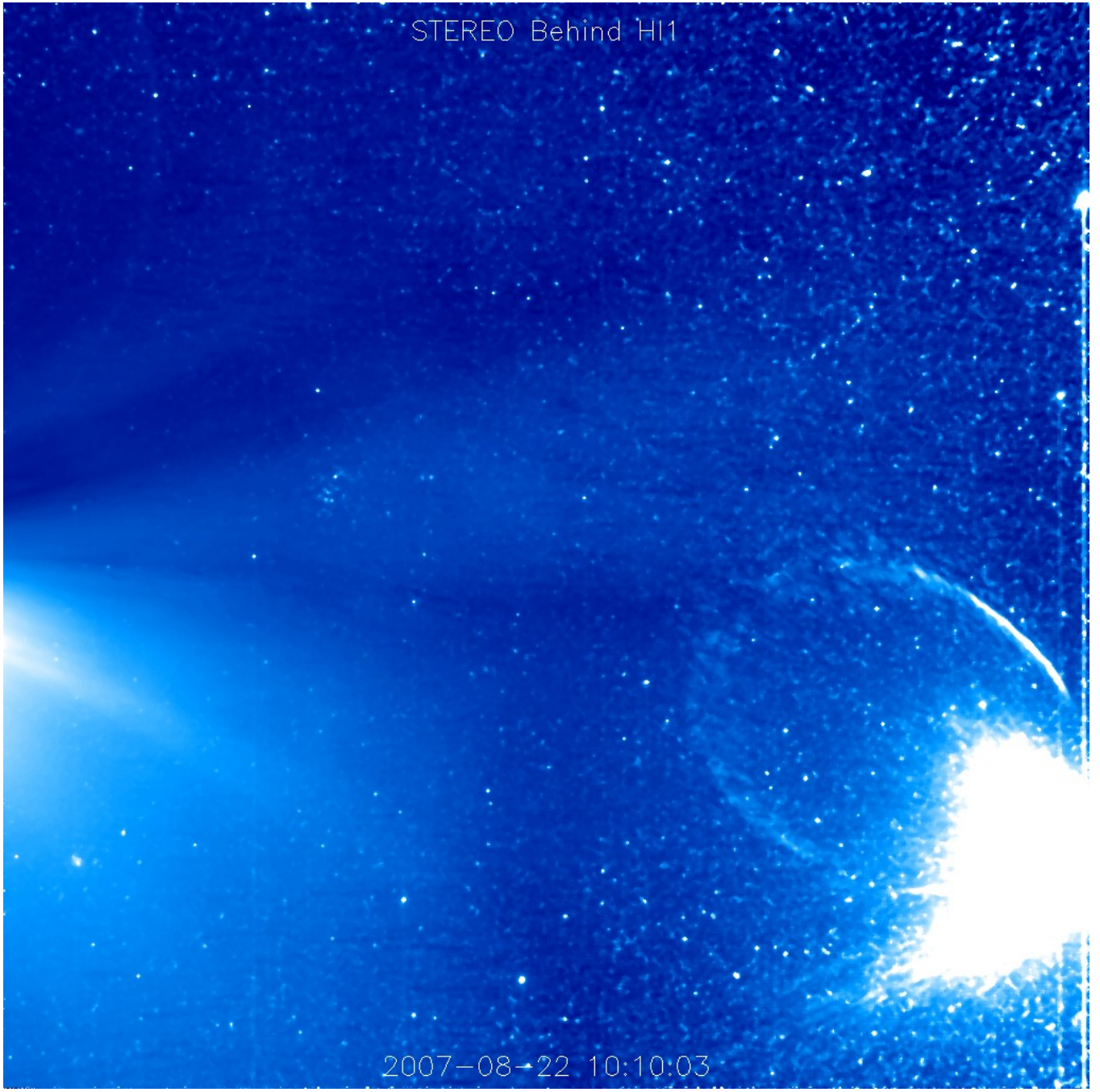
Curt A. de Koning

Geometric Localization



Curt A. de Koning

Geometric Localization



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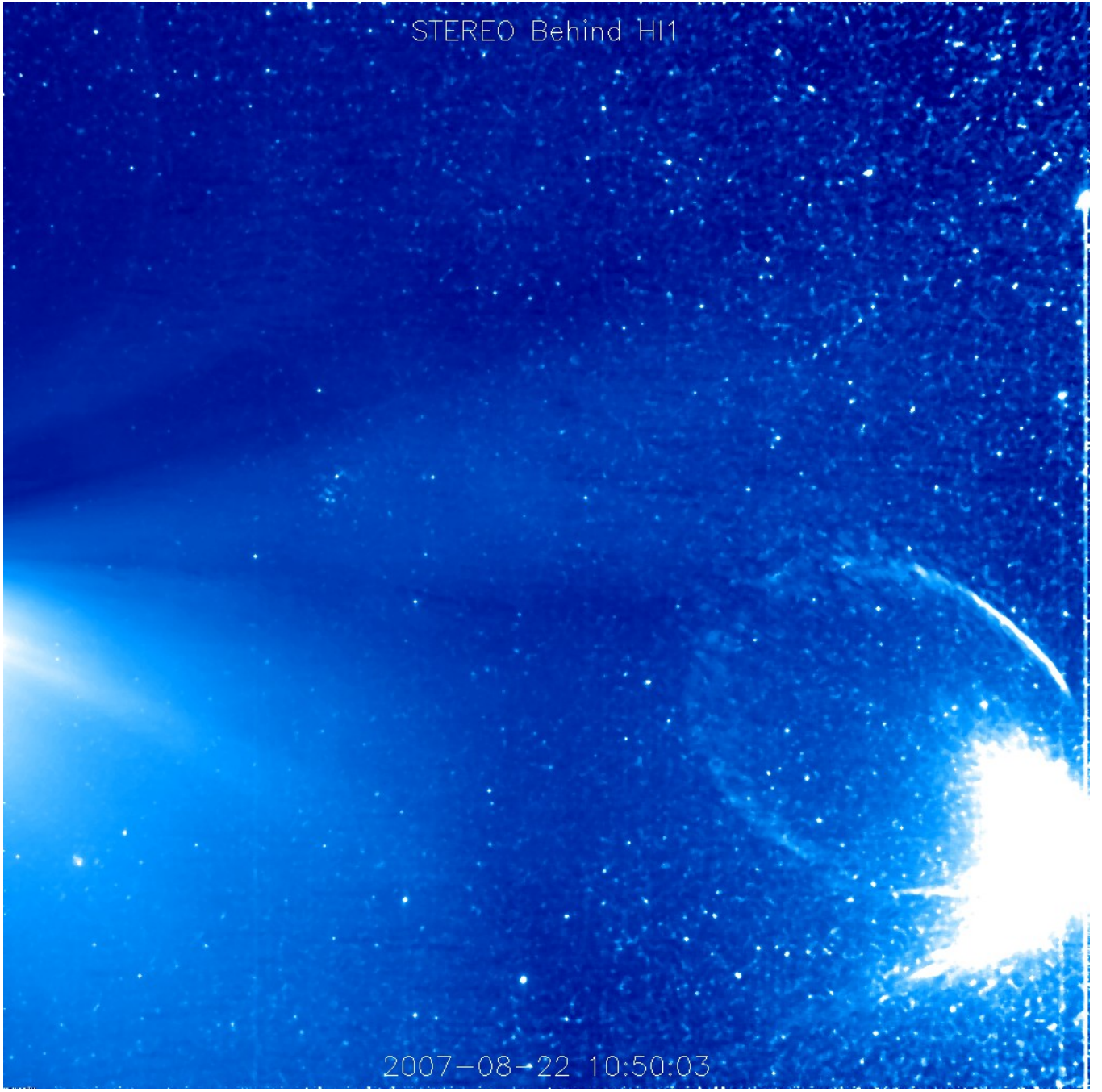
Geometric Localization



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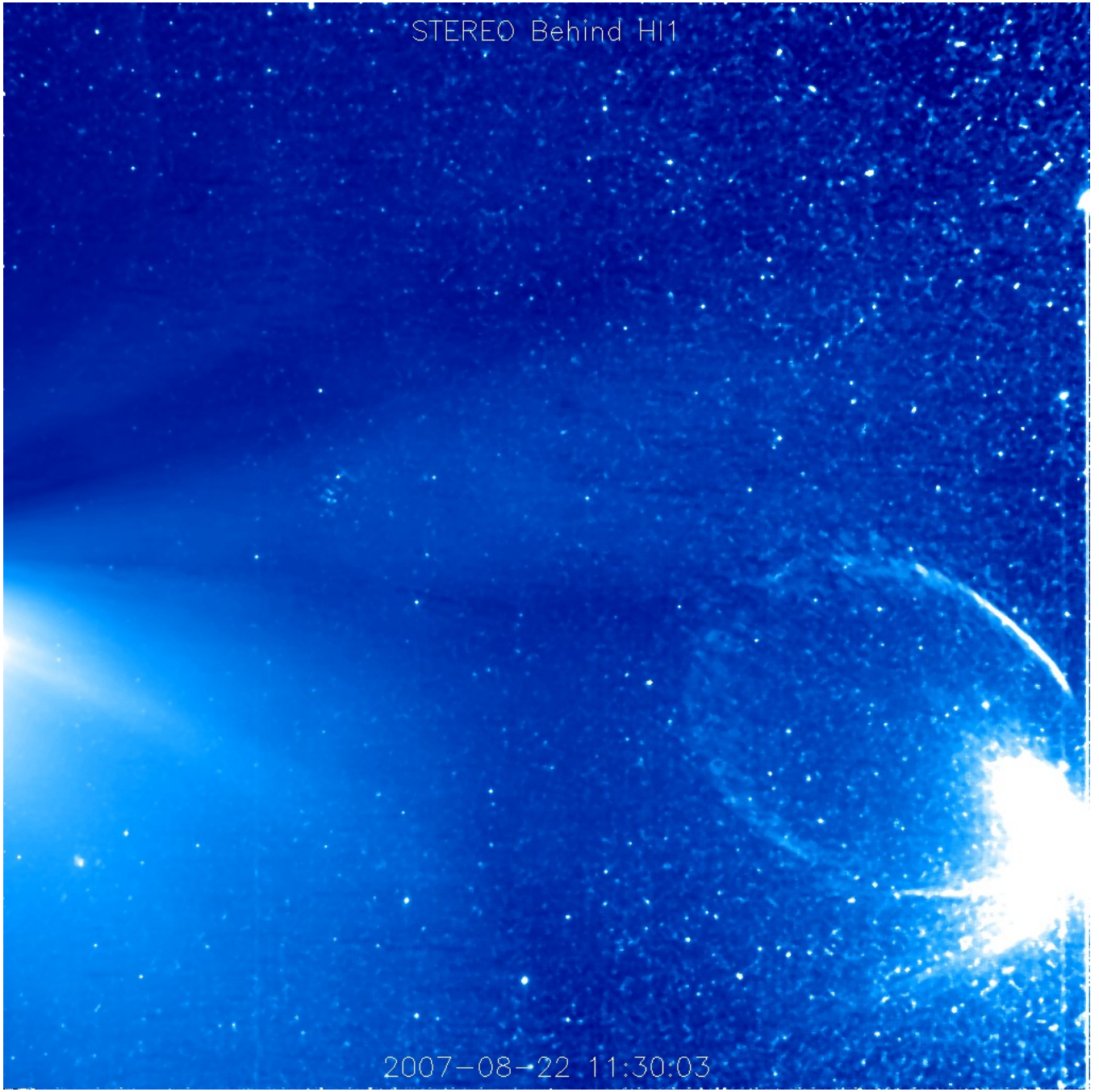

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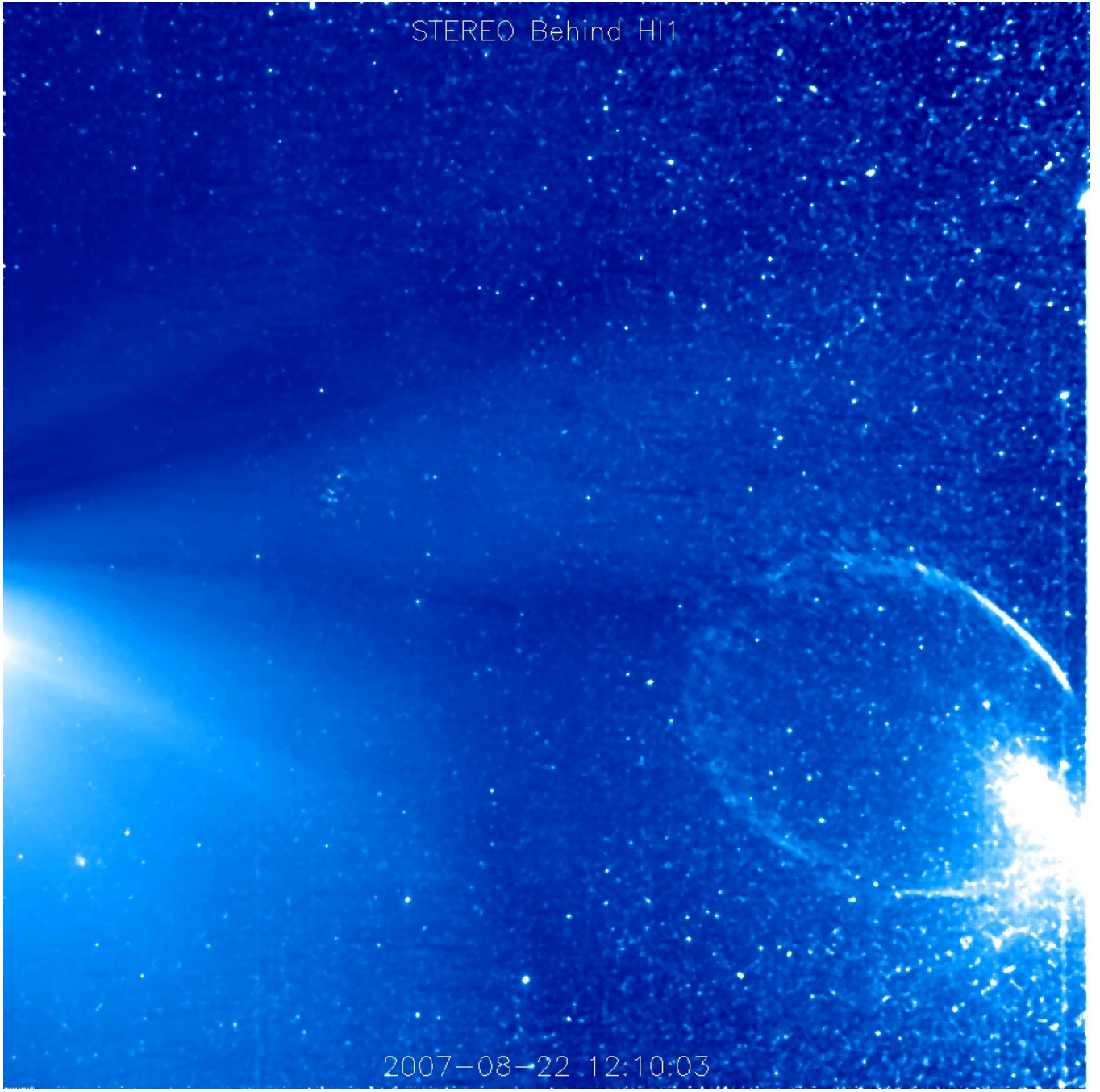

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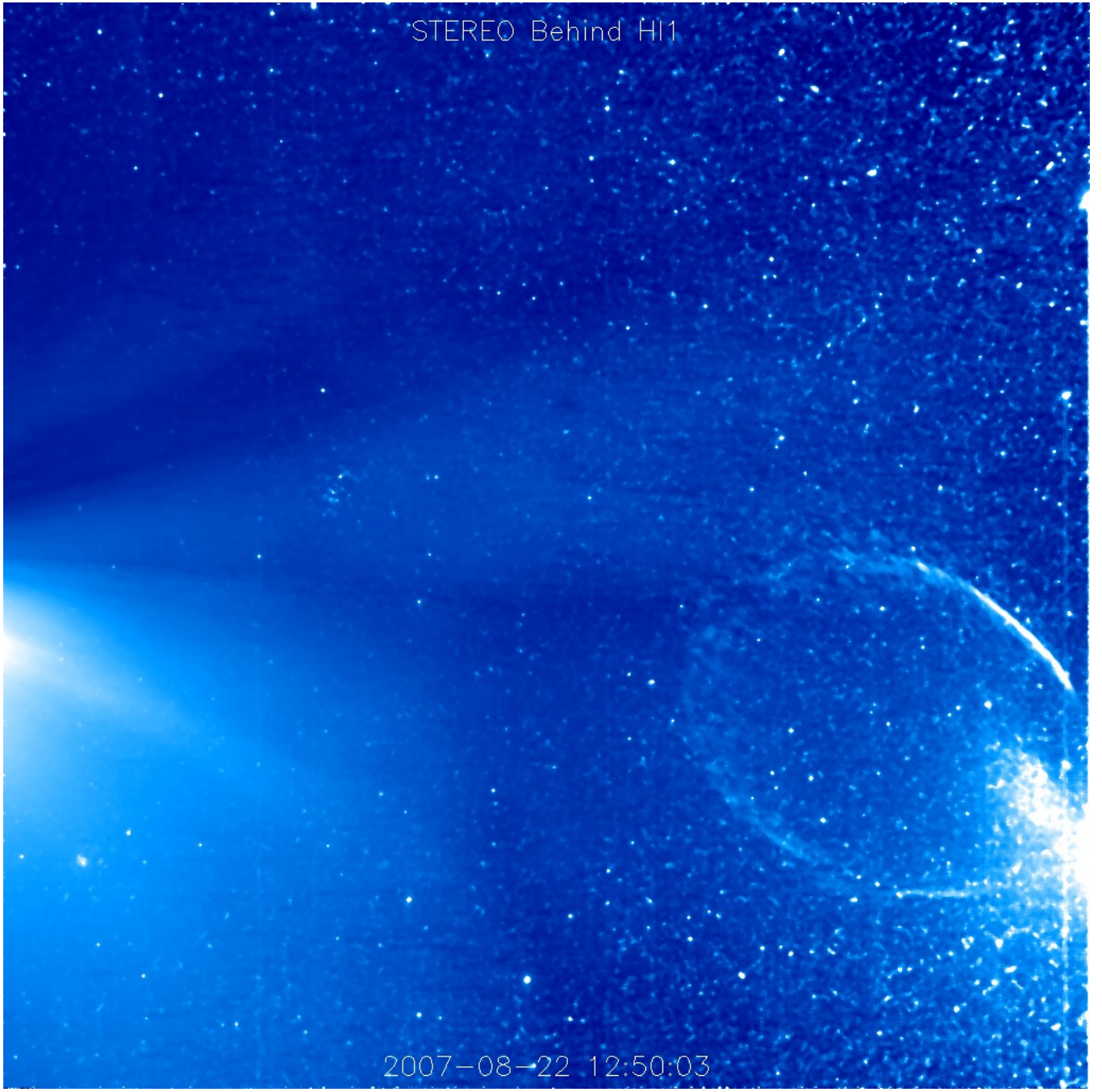
Geometric Localization



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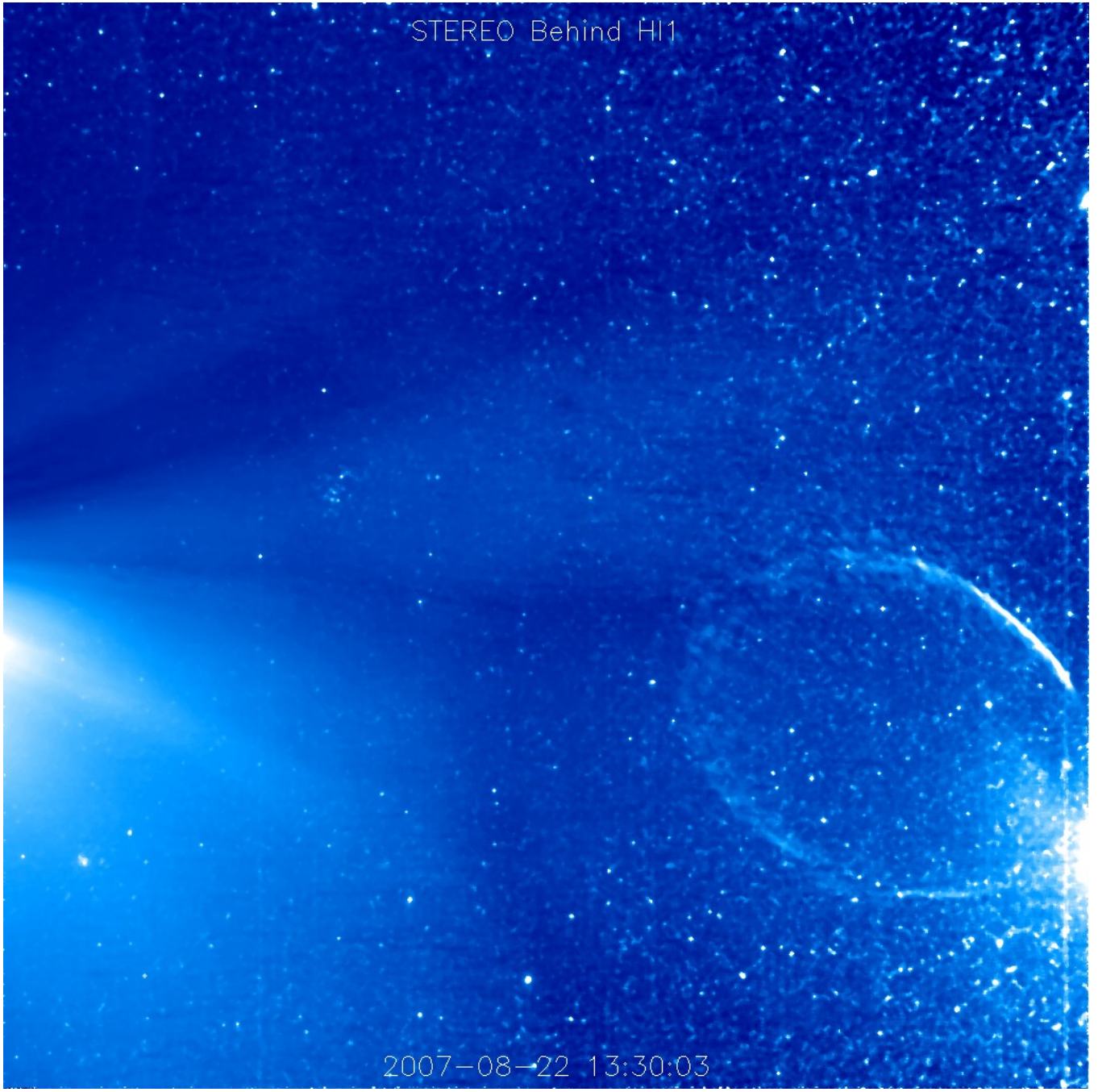
Geometric Localization



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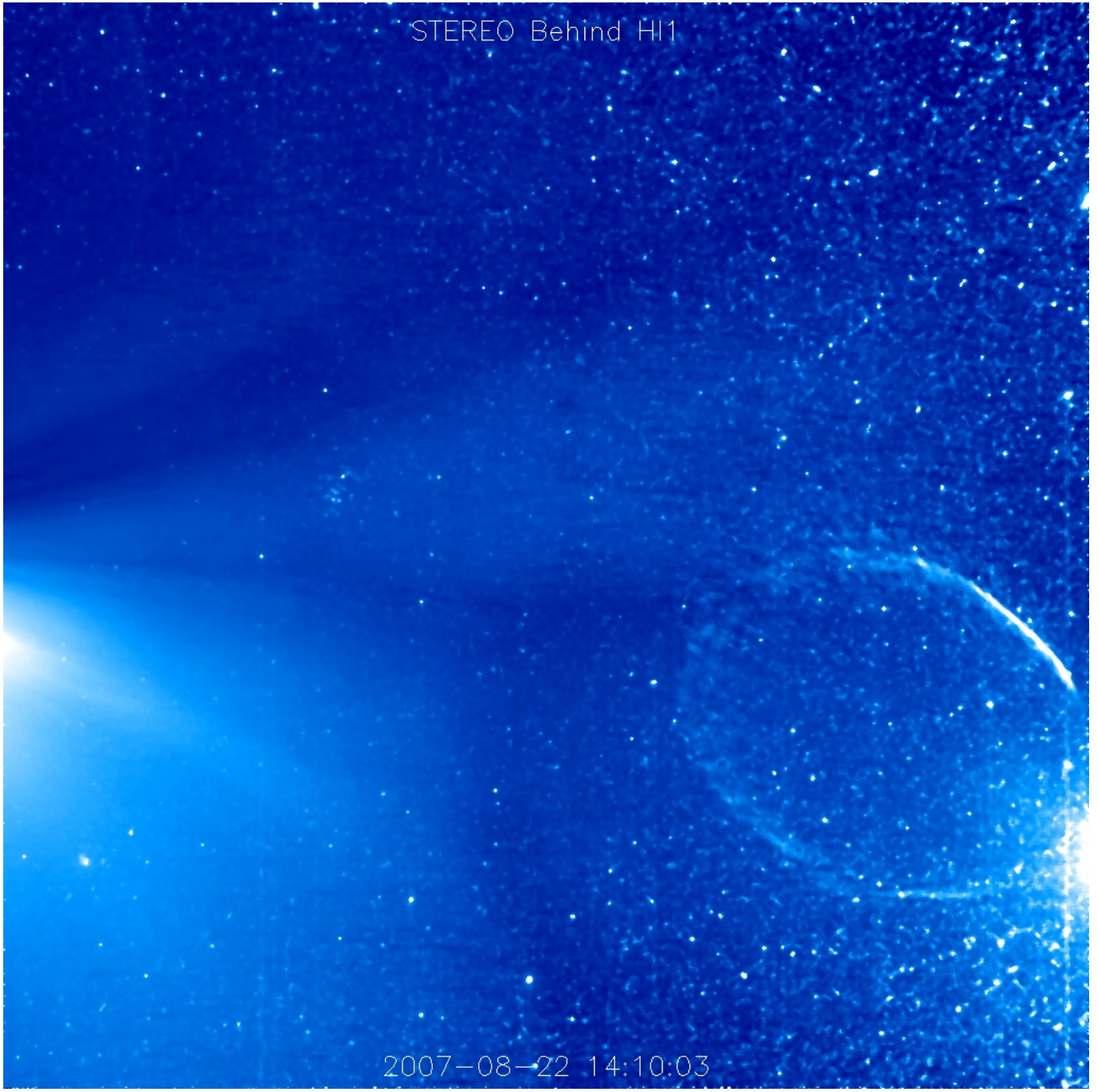
Geometric Localization



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To replay movie, poke Opus in the eye

Curt A. de Koning

Conclusions

- first application of geometric localization technique to STEREO data
- Velocity of 21 August 2007 CME is

  $V_r = 257 \pm 29\,\mathrm{km{\cdot}s^{-1}}$.

  $V_\theta = 7^\circ \pm 3^\circ\,\mathrm{S}$

  $V_\phi = 124^\circ \pm 9^\circ\,\mathrm{W}$
- for 26° separation of spacecraft, repeated application of technique yields reasonable errors

Future Work

- include heliographic latitude of spacecraft in geometric localization analysis of CMEs
- apply polarization analysis alongside geometric localization technique
- compare geometric localization results with other reconstruction techniques
- more events!!!