Study of the striae in the tail of Comet Lovejoy as a diagnostic tool for coronal density

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

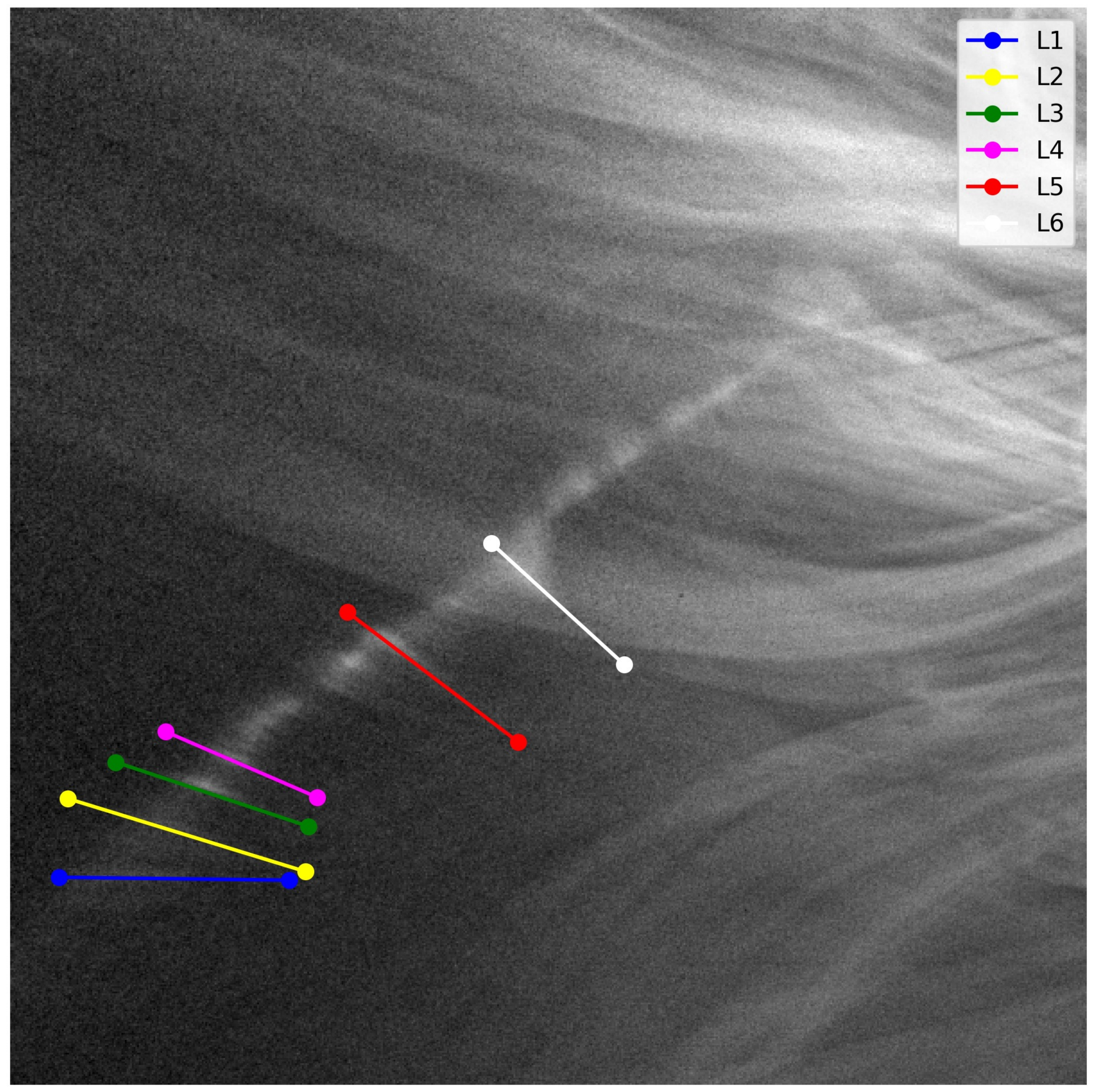
G. Nisticò(1), G. Zimbardo(1), S. Perri(1), V. M. Nakariakov(2), T. Duckenfield(3), M. Druckmüller(4)

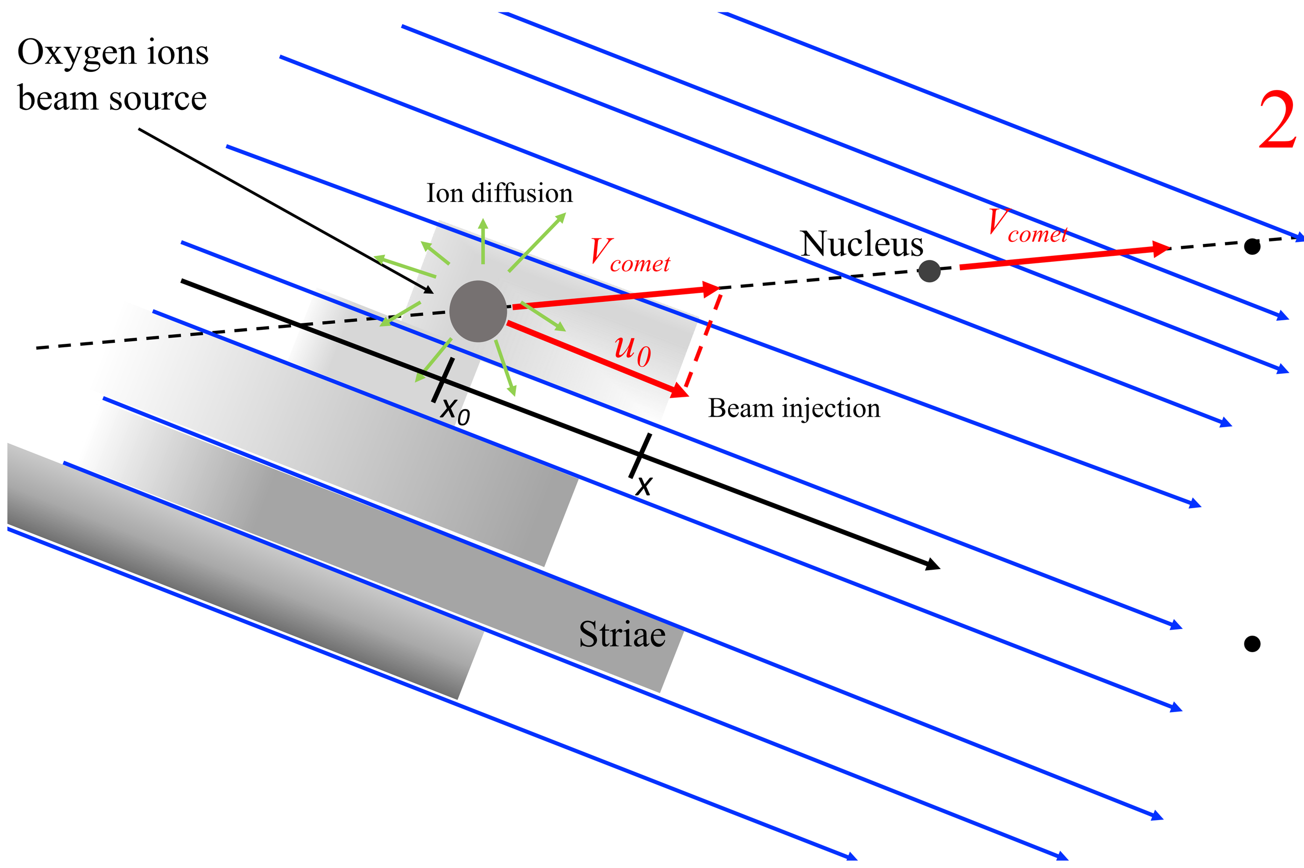
(1)University of Calabria, IT, (2)University of Warwick, UK, (3)KU Leuven, Belgium, (4)Brno University of Technology, Czech Republic

** e-mail: giuseppe.nistico.fis@unical.it*

1. Context and aims

- Comet Lovejoy was observed transiting in the solar corona in Dec 2011 by SDO/AIA [1].
- The comet tail was structured in *striae* due to the EUV emission of oxygen ions O^{5+} released by the nucleus and injected along the magnetic field $\vec{B}$ [2].
- We carry out a preliminary study of the striae evolution during the ingress phase of the comet orbit using SDO/AIA images at 171 Å.





2. Modeling of the striae

- Beam of oxygen ions along the local $\vec{B}$, whose length is determined by the beam velocity, which decays because of collisions, and the ion collisional diffusion.
- Both the collision time for velocity decay and the diffusion coefficient depend on the ambient plasma density.
- Probabilistic description of the ion beam density *n*: the beam position is given by the velocity decay and the spreading of diffusing ions is described by a Gaussian probability distribution [3,4].

$$n(x,t) = \int_0^t dt' \int_{-\infty}^{+\infty} dx' Q(x',t',t) P(x-x',t-t') \quad \text{(1) (Ion density)}$$

$$Q(x',t',t) = \eta(t)\Phi(t')\delta(x'-\Delta x(t')) \quad \text{(2) (Source term)}$$

$$P(x-x',t-t') = \frac{1}{\sqrt{4\pi D_{xx}(t-t')}} \exp\left[\frac{(x-x')^2}{4D_{xx}(t-t')}\right] \quad \text{(3) (Propagator)}$$

Function or parameter	Description
$\eta(t) = \eta_0 \exp(-t/\tau_L)$	Ion beam age
τ_L	Ion lifetime
$\Phi(t') = \Phi_0 \exp(-t'/\tau) G(t')$	Ion flux
τ	Decay time of the beam
$G(t') = \frac{1}{\sqrt{2\pi\sigma_{t_0}}} \exp\left[-\frac{(t'-t_0)^2}{2\sigma_{t_0}}\right]$	Ion injection function
t_0	Injection time
σ_{t_0}	Time interval for ion injection
$\Delta x(t') = x - x_0 = u_0\tau\,[1-\exp(-t'/\tau)]$	Motion of the beam
u_0	Beam speed along the magnetic field
$D_{xx} = \frac{1}{3} v_{th}^2 \tau_D$	Diffusion coefficient
v_{th}	Thermal speed
τ_D	Diffusion time

3. Data processing and analysis

- Profiles of emission intensity along the magnetic field are computed and compared with the profiles along the striae observed by AIA.
- Observed profiles are extracted from an artificial slit and normalised to the peak intensity. We show the profiles from slit L5 (blue lines).
- Simulated profiles (red lines) are obtained by squaring the density obtained from the numerical integration of Equation (1) with the following values of the parameters:

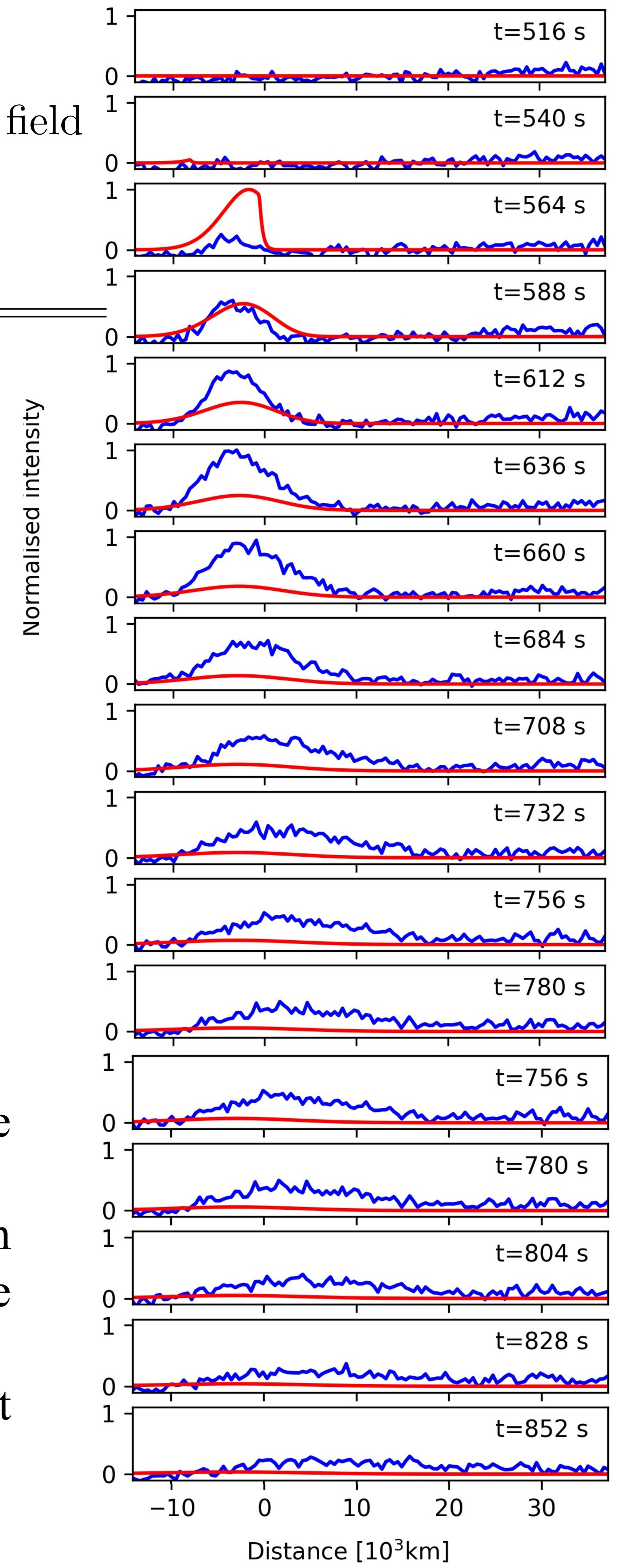
$\Phi_0 = 1.0$ $\quad \eta_0 = 1.0$ $\quad v_{th} = 150$ km s^{-1}

$u_0 = 400$ km s^{-1} $\quad \tau_D = 25$ s $\quad \tau = 150$ s

$t_0 = 40$ s $\quad \sigma_{t_0} = 10$ s

4. Discussion and conclusions

- The simulated profiles are qualitatively in agreement with the observed ones.
- Better matching of the intensity peak position in space and time can be achieved by systematically looking for the best values of the parameters.
- Determination of τ and τ_D allows getting information on the ambient coronal density [5].



References

[1] Downs et al., Science, 2013.
[2] Pesnell and Bryans, ApJ, 2014.
[3] Ragot & Kirk, A&A, 1997.
[4] Perri & Zimbardo, JGR, 2008.
[5] Nisticò et al. in preparation.