Effect of resolution on damping of propagating slow magneto-acoustic waves in the solar corona

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Abstract

Slow magneto-acoustic waves were observed in the fan loops of active region NOAA AR12712 from Hi-C 2.1 and SDO/AIA. The frequency and propagation speeds of the waves were found to be the same in both the instruments. Damping lengths were calculated by two different methods. From the phase tracking method, it was calculated as 5.9 ± 1.9 Mm for AIA and 3.5 ± 0.7 Mm for Hi-C 2.1, while from the amplitude tracking method it was calculated as 3.4 ± 0.6 Mm for AIA and 3.0 ± 0.3 Mm for Hi-C 2.1. All these values are matching to each other hence, for this set of observation there is no effect of resolution on damping.

Introduction

Outward propagating intensity oscillations are a common observational feature in active region fan loops. Interestingly, their amplitude gets damped over a length scale of 8.9 ± 4.4 Mm (see De Moortel et al. 2002). Recently, Meadowcroft et al. (2023) have reported different damping lengths for the same loop when observed from SDO/AIA and SolO/EUI. This is alarming and the science behind this remains unknown. So, we compare the damping lengths of the slow waves observed from a different pair of equipment.

Data Used

The High-Resolution Coronal Imager (Hi-C 2.1) observed the AR 12712 at 172Å for 335s (cadence : 4.4s, pixel size: 0.129”). The data suffers from jitter due to pointing instability and hence, was time-averaged to two frames and was also shortened to 304s. The Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO) observes sun in various EUV channels, out of which the data of channel centered at 171Å was used. Observations of duration 30 minutes (cadence :12s, pixel size : 0.6”) with starting time and field of view same as Hi-C. For tracking the same loop in both the data, they were co-aligned.

Analysis & Results

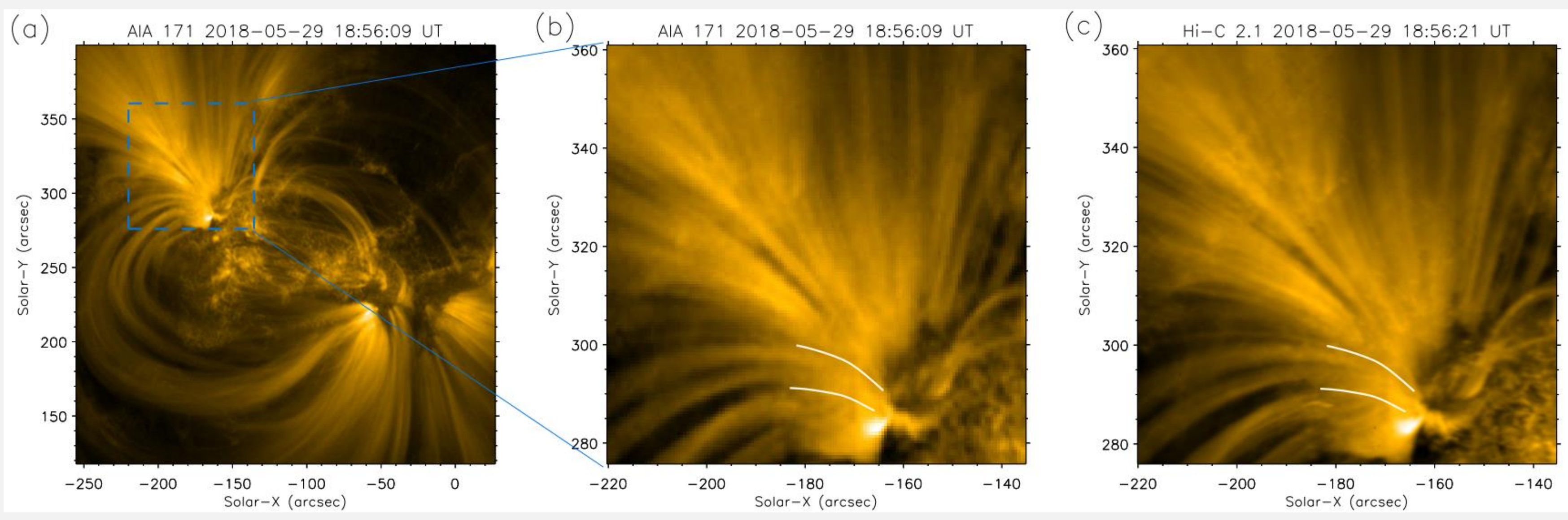

Figure 1. (a) Snapshot of AR12712 in the 171Å of SDO/AIA. The box marked by blue dashed line shows the region zoomed in. (b) & (c) Snapshot of the co-aligned data, white line mark the boundaries of the loop where propagating waves were found

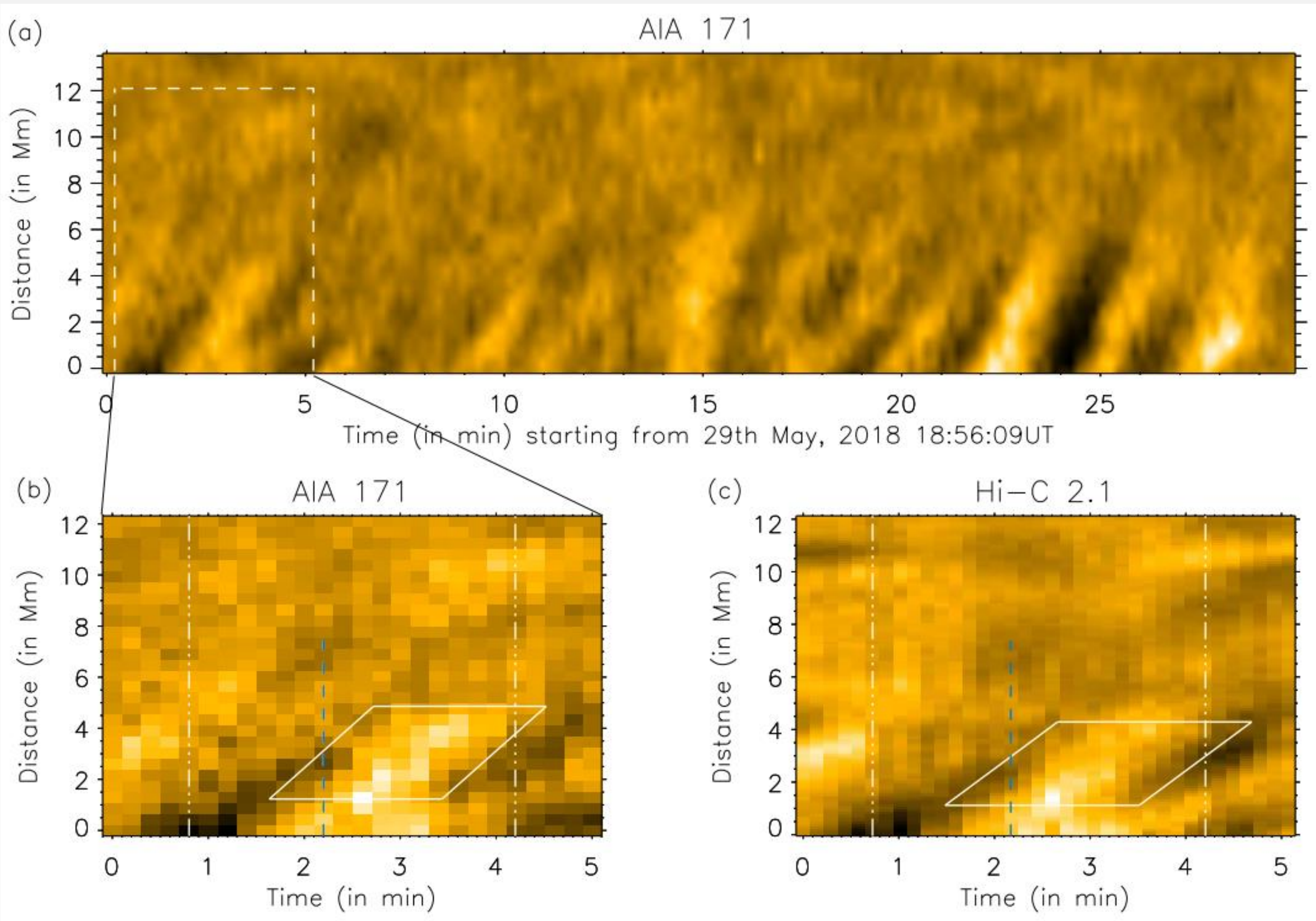

Figure 2. Relative intensity time-distance map are created by averaging intensities across the loop and stacking them in time-domain followed by appropriate background subtraction (a) for full duration of AIA, (b) for AIA in duration of Hi-C, (c) for Hi-C; (a) : Vertical dashed white lines mark the starting and ending time of Hi-C 2.1 data; (b) & (c) : White parallelogram mark the region used for velocity calculation, vertical blue dashed line mark the location of the intensity profile used in phase tracking method. The vertical white dot-dashed line mark time between which the maps are cropped for amplitude tracking method.

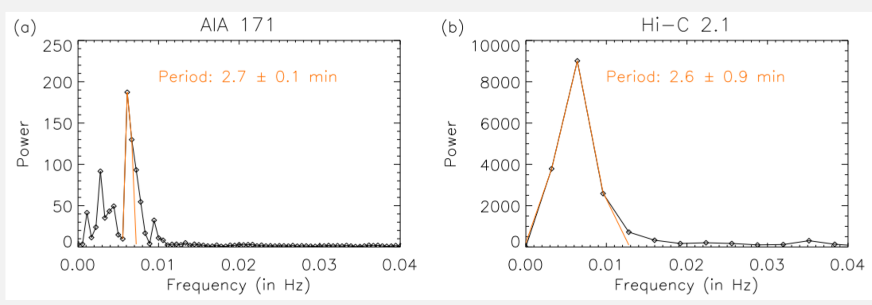

Figure 3. Power averaged till 6 Mm v/s Frequency for (a)AIA (b)Hi-C 2.1. The peak frequency was fitted to gaussian to get the time period along with error as 2.7 ± 0.1 min for AIA and 2.6 ± 0.9 min for Hi-C 2.1

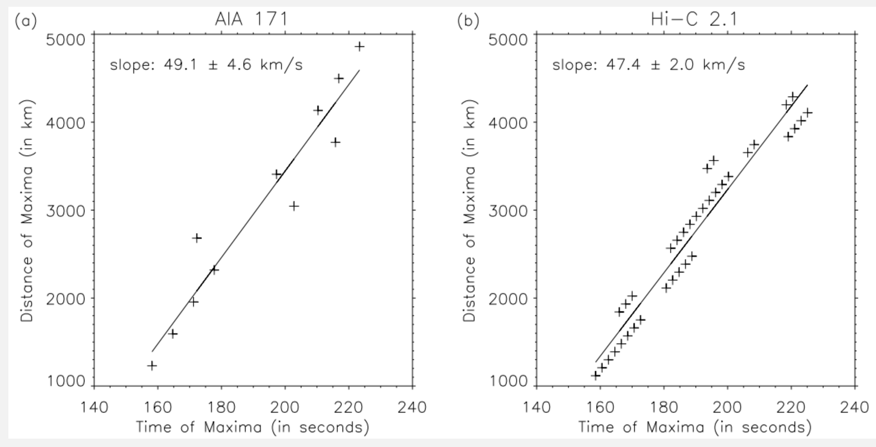

Figure 4. Plots of Distance v/s Time of intensity maxima found in regions marked in Figure 2 (b) & (c). Slope of this gives propagation speed as 49.1 ± 4.6 km/s in AIA and 47.4 ± 2.0 km/s in Hi-C 2.1

Phase Tracking Method

The spatial relative intensity profiles along with their errors are fitted to an exponentially decaying sinusoid of the form,

$$I(x) = I_0 e^{\left(-\frac{x}{L_d}\right)} \sin\left(\frac{2\pi x}{\lambda} + \varphi\right) + B_0 + B_1 x$$

Amplitude Tracking Method

The temporal profile at each pixel was cropped to isolate the contribution from central ridge and then these profiles were used to compute the standard deviation(σ) and hence the amplitude A= σ√2; which is then fitted to

$$A(x) = A_0 e^{\left(-\frac{x}{L_d}\right)} + C$$

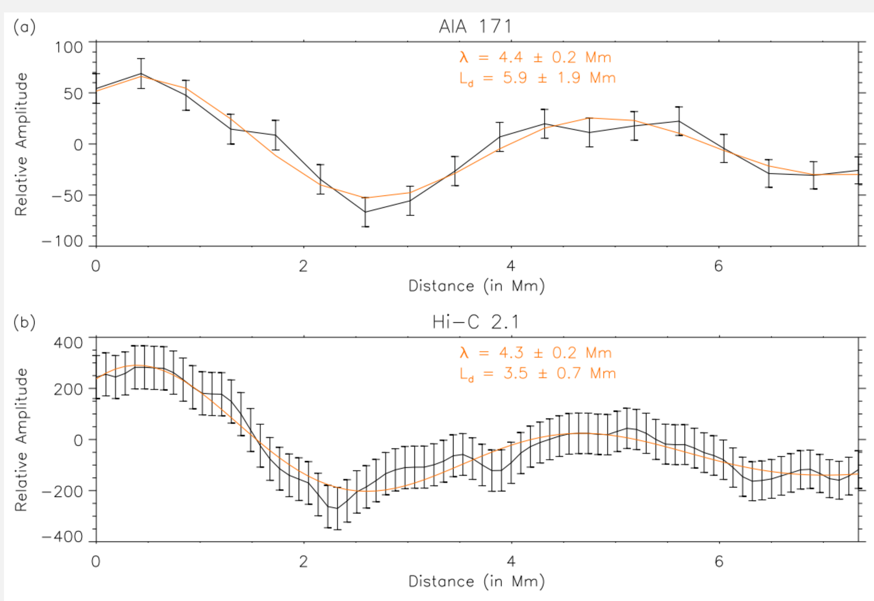

Figure 5. Relative intensity v/s distance along the location marked by blue dashed line in Figure 2 (b) & (c) for (a)AIA (b)Hi-C 2.1. The solid black lines denote the data, and the vertical bars denote the respective uncertainties. The orange line depicts the best fit 5.9 ± 1.9 Mm for AIA and 3.5 ± 0.7 Mm for Hi-C 2.1

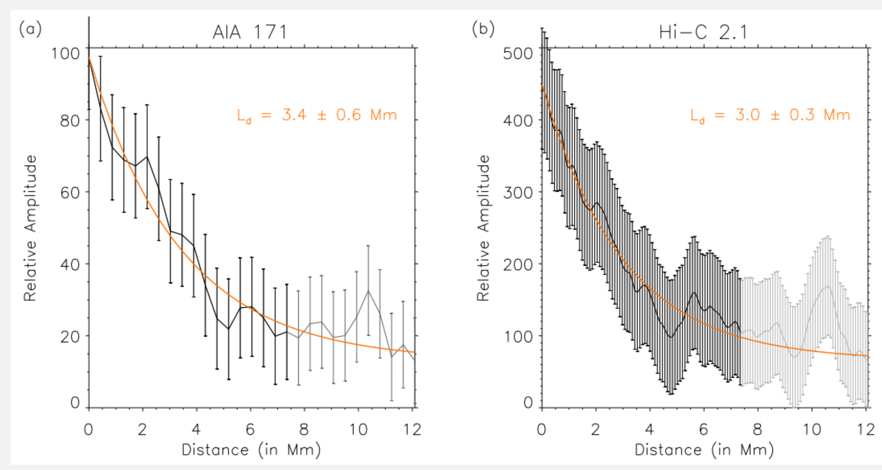

Figure 6. Amplitude v/s distance along the loop for (a)AIA (b)Hi-C 2.1. The solid black lines denote the data used for fit while the grey ones are ignored. The vertical bars denote the respective uncertainties. The orange line depicts the best fit 3.4 ± 0.6 Mm for AIA and 3.0 ± 0.3 Mm for Hi-C 2.1

Conclusion

The frequency and speed values for AIA and Hi-C 2.1 match to each other. This confirms that we are looking at same outward propagating oscillations from both the instruments. The velocity of these waves are less than the local sound speed (~140km/s) hence, it is slow magneto-acoustic waves. The damping length values calculated by different methods are same hence, for this set of observation there is no effect of resolution on damping. To check the prevalence of such results, various loops hosting slow waves are identified in SolO/EUI and their damping lengths will be compared with SDO/AIA.

References

De Moortel, I., Ireland, J., Walsh, R. W., & Hood, A. W. 2002, Sol. Phys., 209, 61

Meadowcroft, R. L., Zhong, S., Kolotkov, D. Y., & Nakariakov, V. M. 2023, MNRAS, 527, 5302

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