3D Helical Geometry of the Magnetic Field from VTT Data

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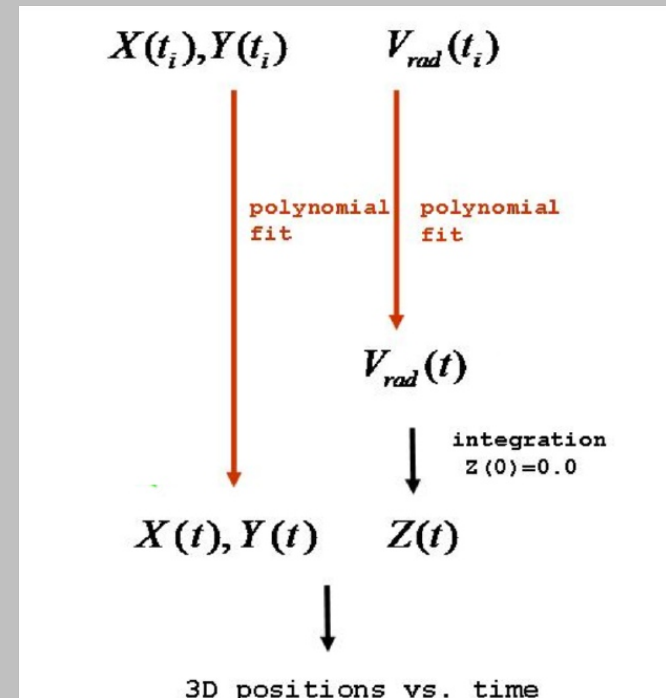
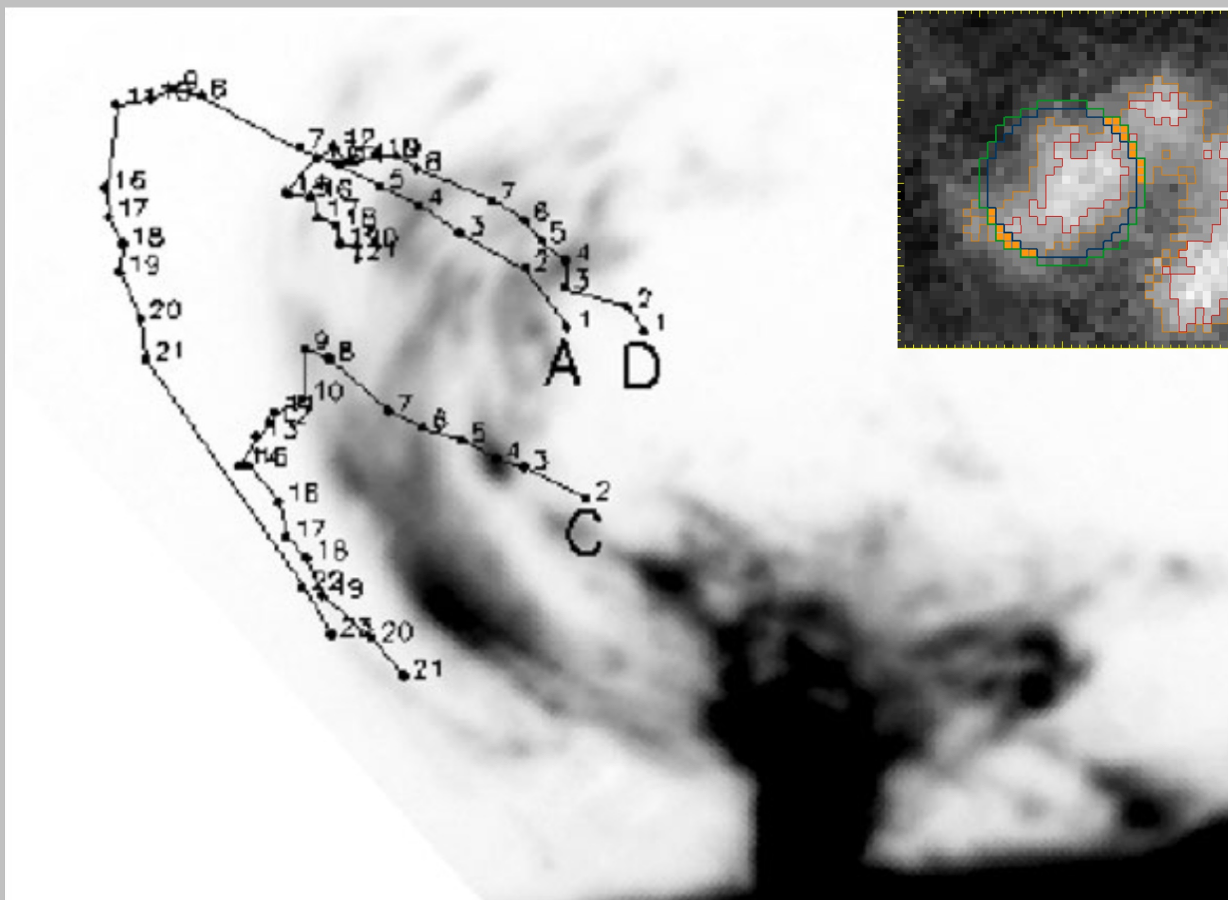
The method

- Observations of knots in prominences
- For low plasma β assumption of knot motion in magnetic flux tubes along magnetic field lines
- Knot trajectory determines magnetic field topology

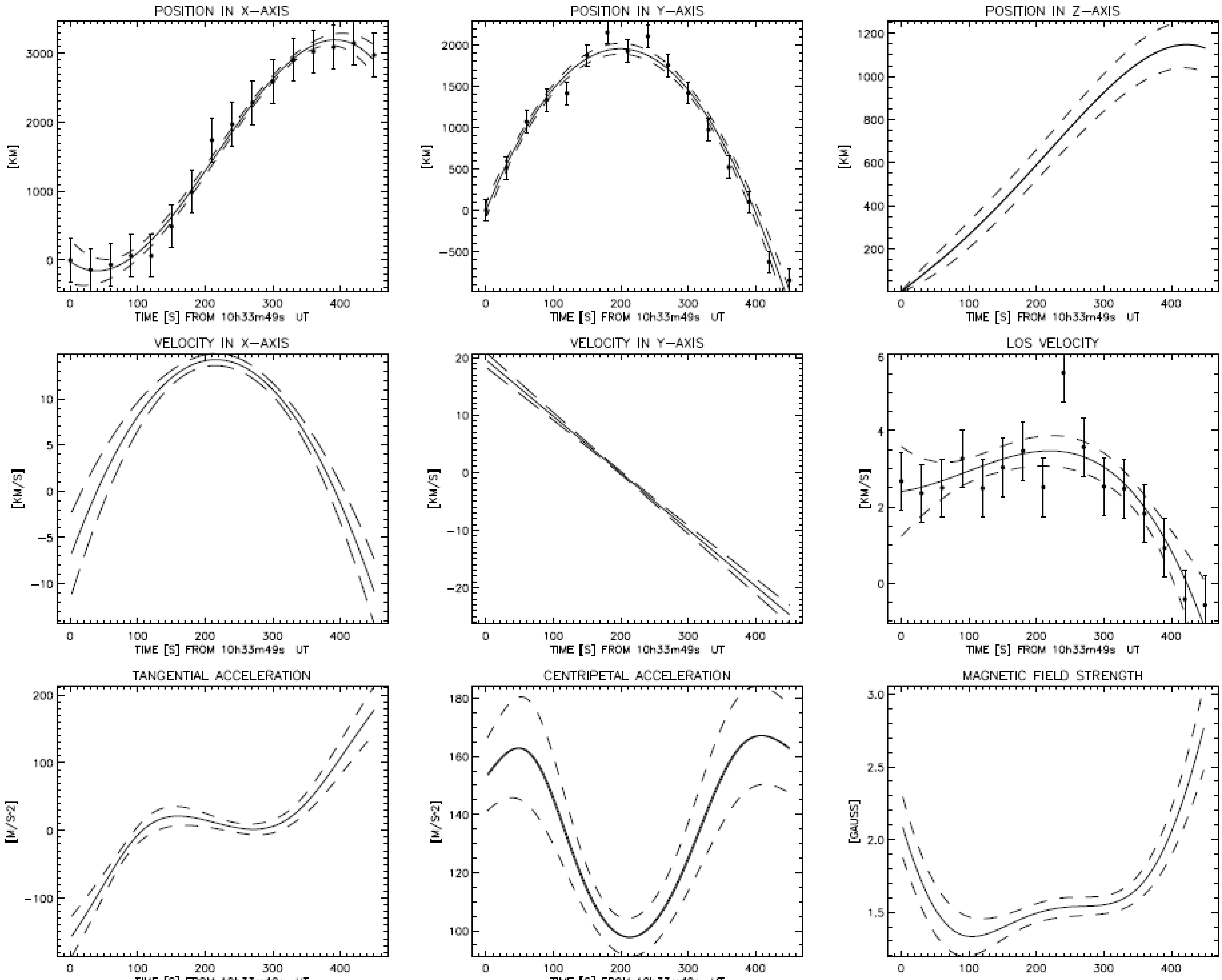




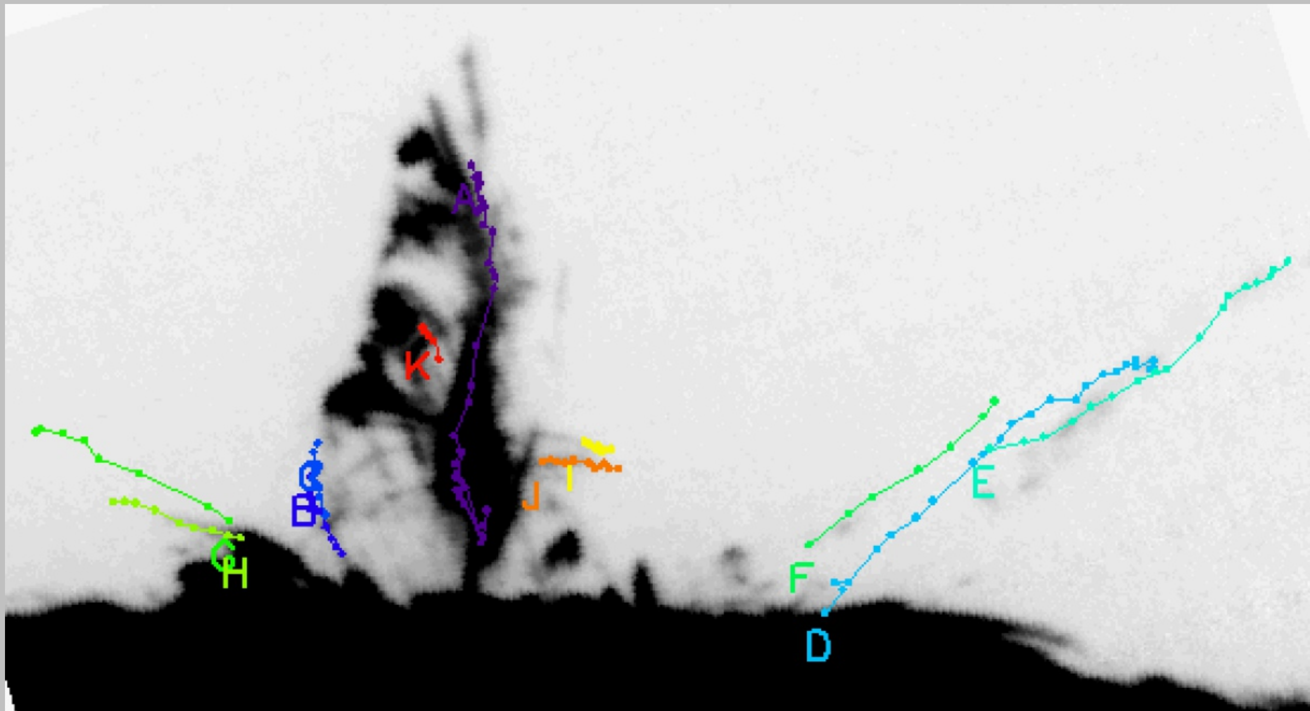
2D plane-of-the-sky positions of knots' observed in the prominence of June 1, 2003 using MSDP in Bialkow.

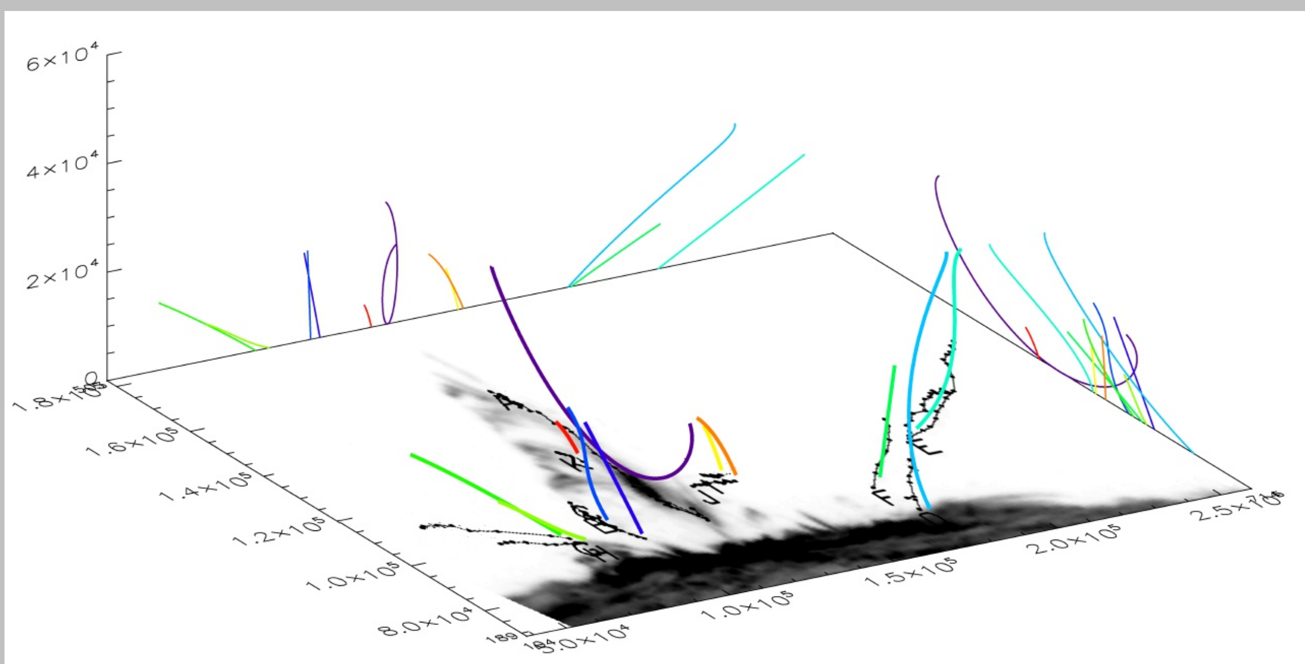
- 2D spectroscopy
- Semi-automatic knot tracking
- Automatic knot delimitation
- Determination of the proper polynomial degree with Chebyshev orthogonal polynomials

Zapiór & Rudawy (2010), *Solar Physics* **267**, 65
Zapiór & Rudawy (2012), *Solar Physics* **280**, 445



POSITION IN X–AXIS
POSITION IN Y–AXIS
POSITION IN Z–AXIS
VELOCITY IN X–AXIS
VELOCITY IN Y–AXIS
LOS VELOCITY
TANGENTIAL ACCELERATION
CENTRIPETAL ACCELERATION
MAGNETIC FIELD STRENGTH
[KM]
[KM/S]
[M/S^2]
[GAUSS]
TIME [S] FROM 10h33m49s UT

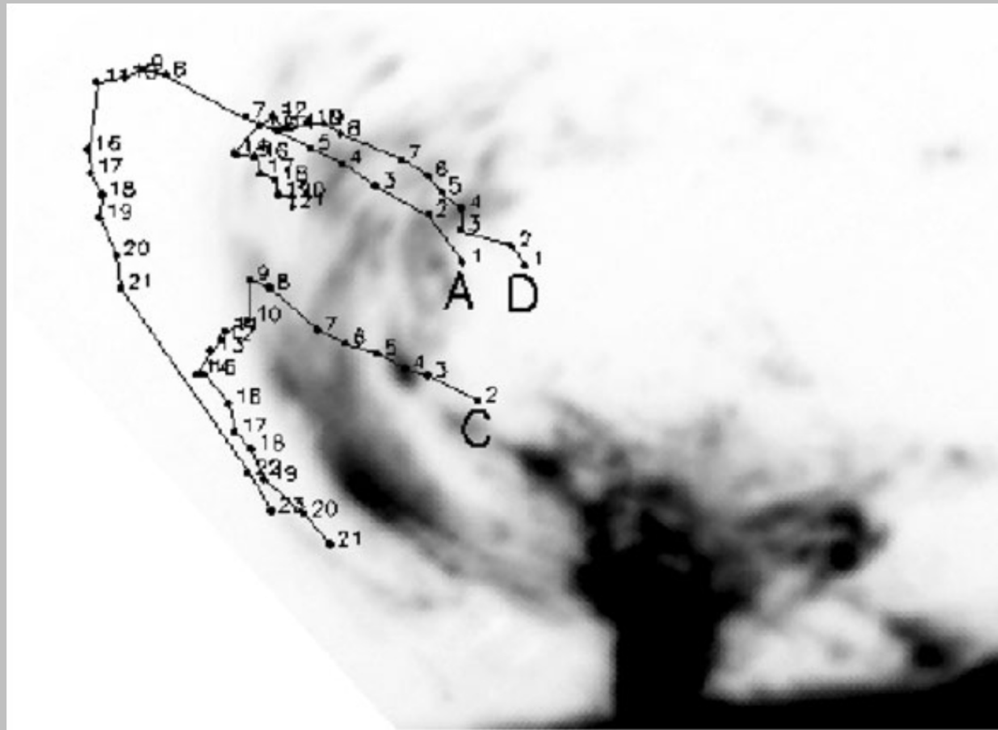


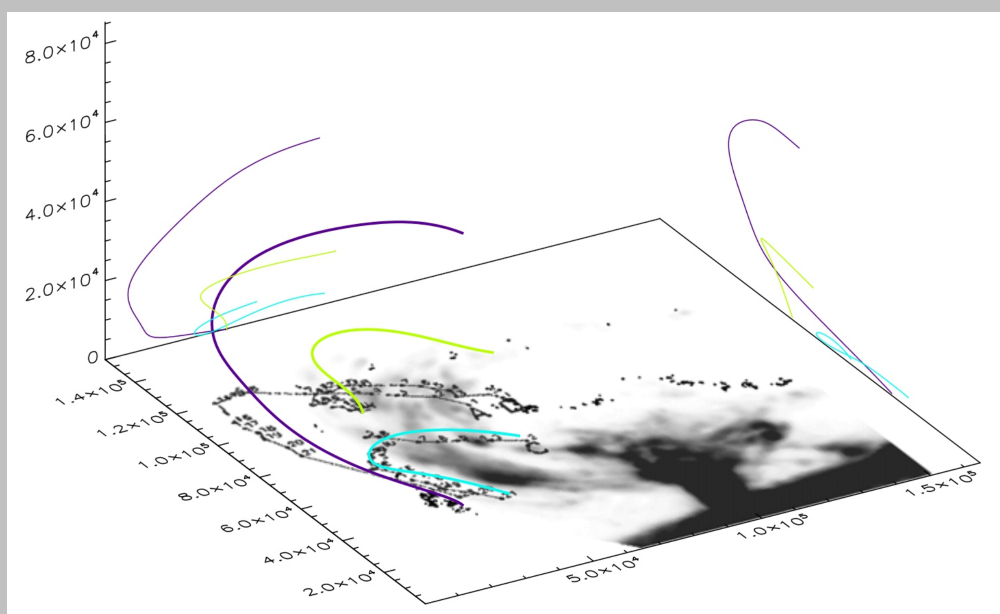


2D

3D

The prominence of July 14, 2005 observed by Bialkow MSDP





2D

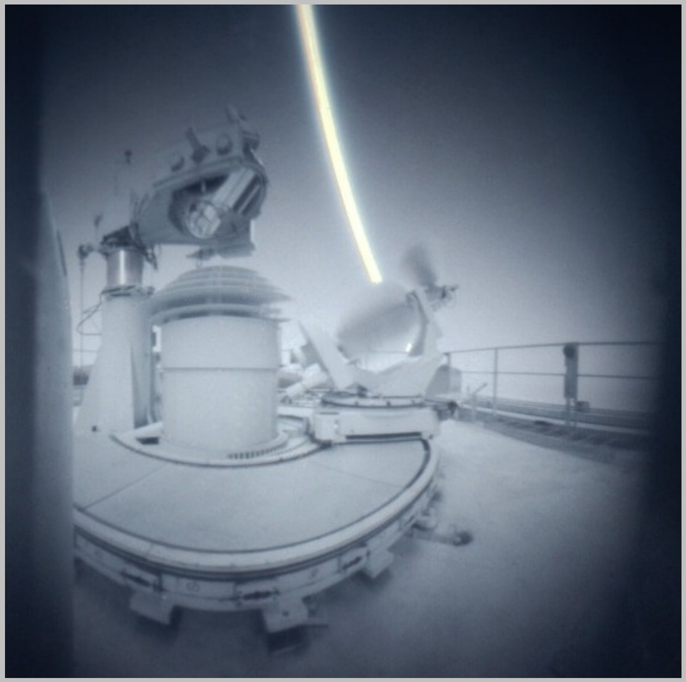
3D

Prominence of June 1, 2003 observed by Bialkow MSDP

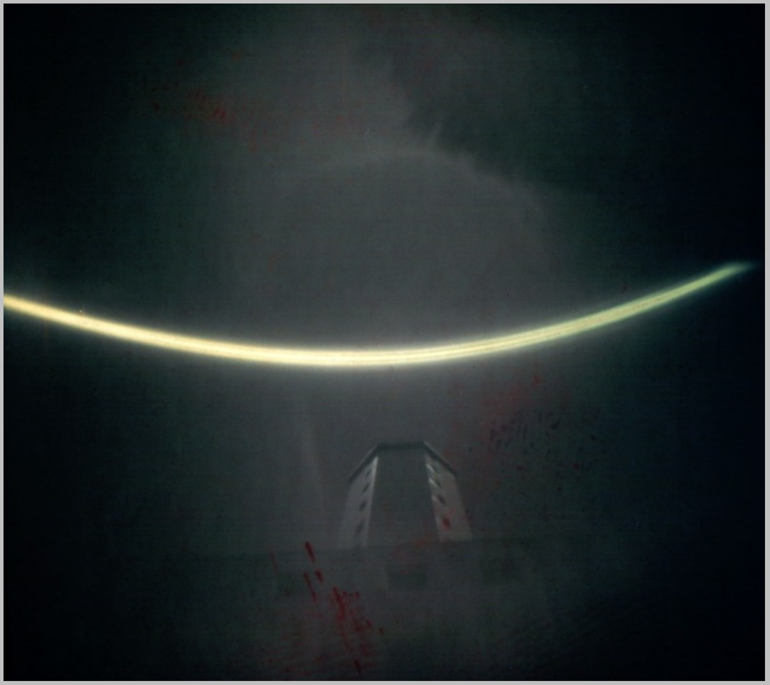
2014 June 9 campaign

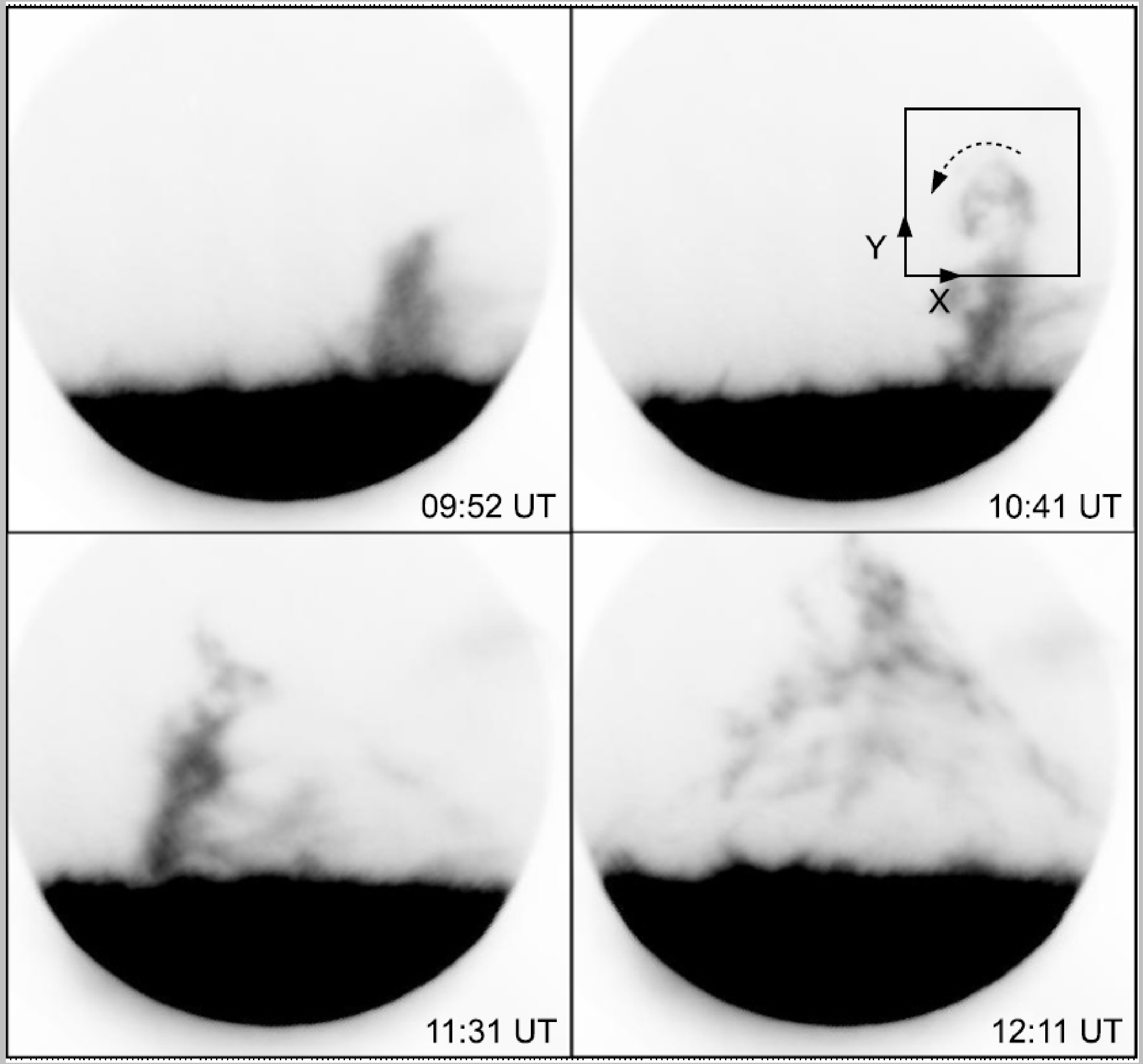
- Teide Observatory in Canary Islands
- VTT (Vacuum Tower Telescope)
- Equipped with a Fabry-Perot tunable interferometer called TESOS (The Triple Etalon SOlar Spectrometer).
- Hα spectral line
- 35 filtergrams taken in different wavelengths along the spectral profile in the range
- +/- 1.6 A from the line centre with step of 0.095 A
- Timecadence 30 seconds
- 09:52 to 12:11 UT
- FOV = 42x42''

Coelostat at the VTT

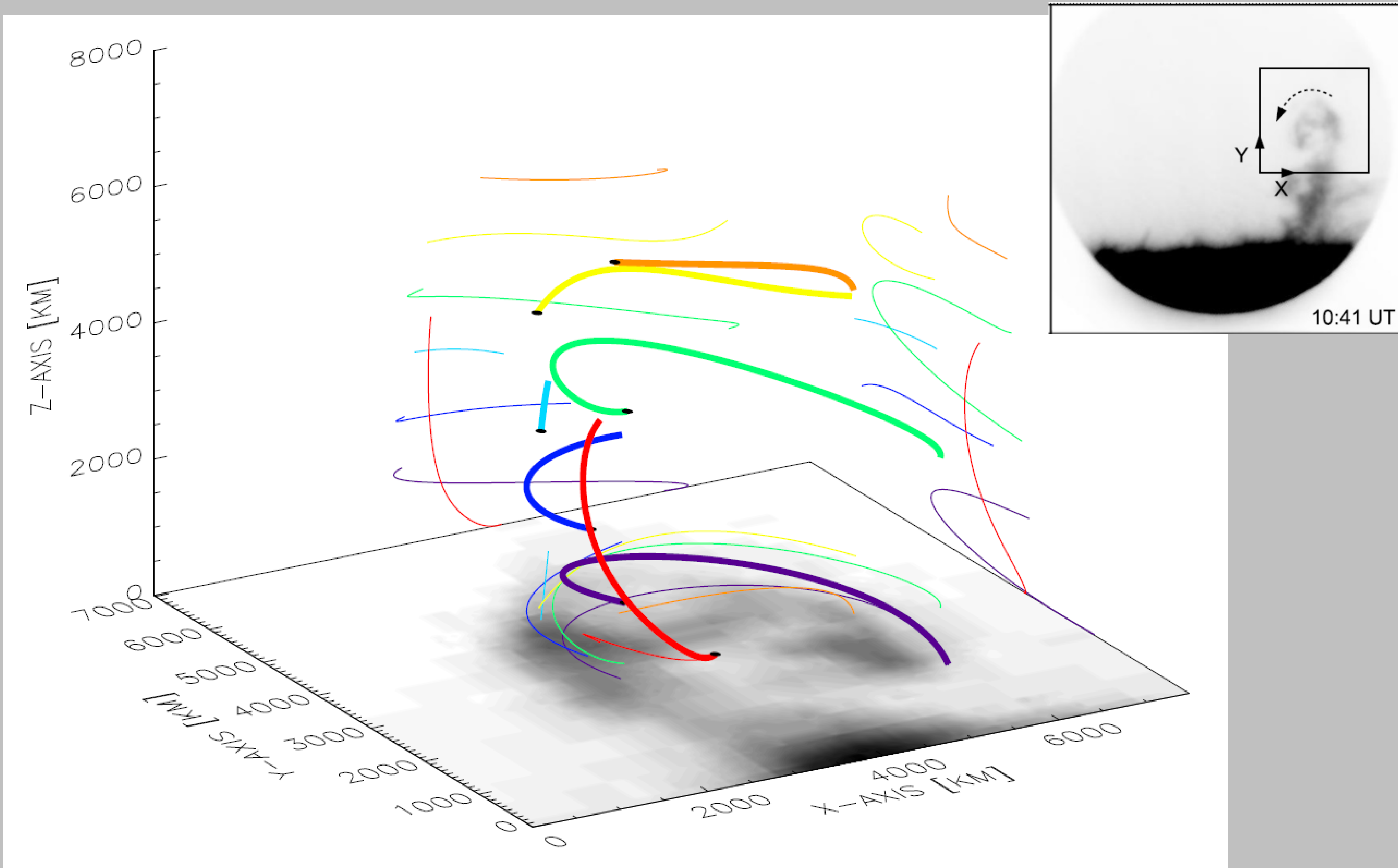


VTT building from the bottom

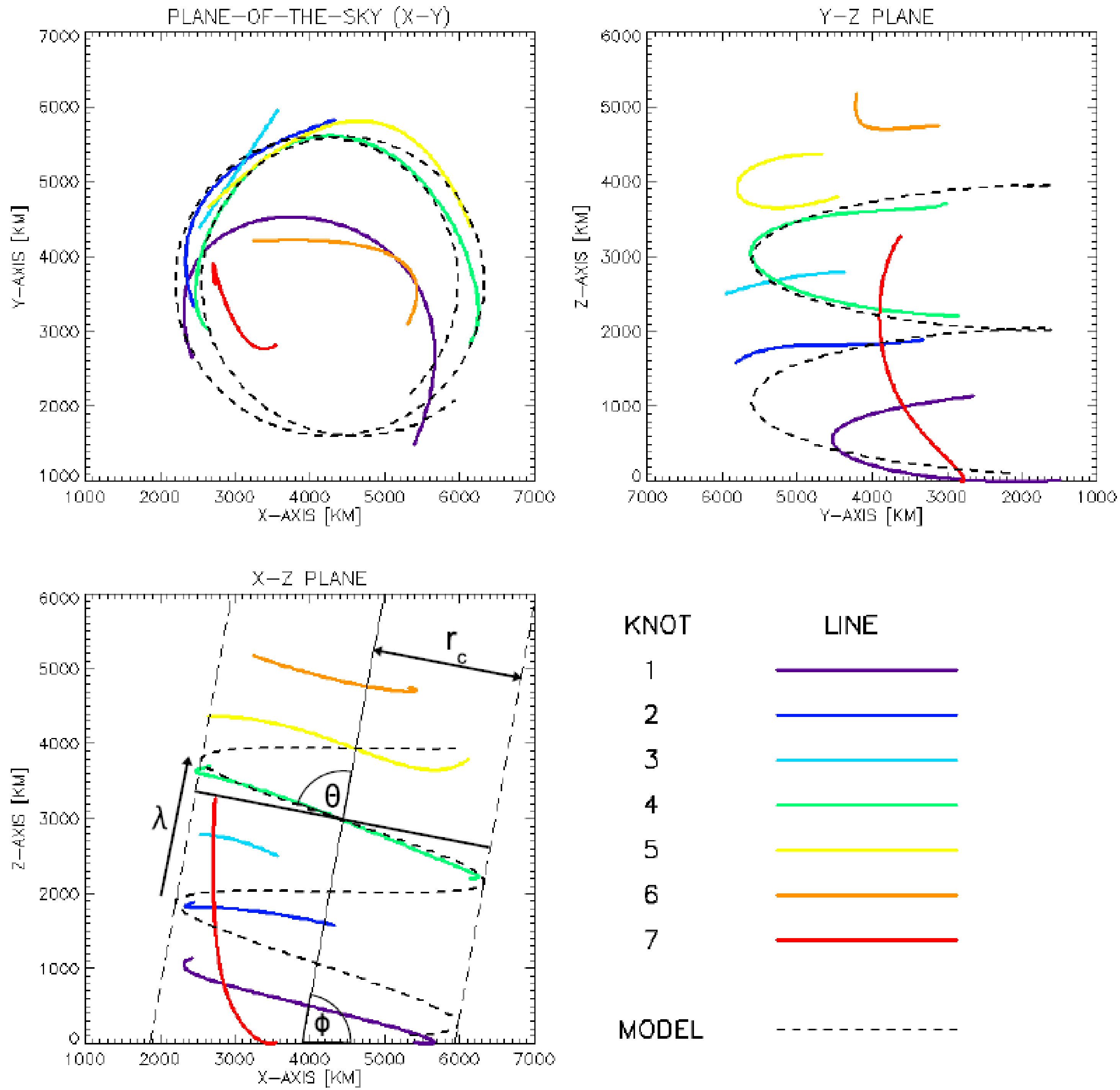




Images of the prominence of 2014 June 9 in Hα taken during observations.



3D trajectories of knots superimposed onto the prominence image (X-Y plane)



Trajectories of knots projected onto parallel planes. Different colours of lines represent particular knots.

Model with

r_c = 2000 km

λ = 2000 km

θ = 81°

ϕ = 80°

is overplotted with black dashed lines.

N	No. of images	t_1 UT	t_n UT	V_{min} kms^{-1}	V_{max} kms^{-1}	θ $^\circ$	r_c km	λ km	B_{min} G
1	16	10:33:49	10:41:19	13.0	27.0	84.8 ±5.0	1955	2050±300	2.7±0.3
2	9	10:38:49	10:42:49	12.6	23.1	92.4 ±5.0	2574	–	2.3±0.3
3	5	10:38:49	10:40:49	16.6	17.3	83.5 ±5.0	7864	–	1.7±0.1
4	15	10:34:49	10:41:49	10.9	21.6	77.3 ±5.0	1894	2640±300	2.2±0.3
5	11	10:37:49	10:42:49	12.2	23.5	79.3 ±5.0	2367	–	2.3±0.3
6	12	10:31:19	10:36:49	5.6	17.7	86.2 ±5.0	2608	–	1.8±0.2
7	20	10:33:19	10:42:49	3.4	10.5	–	–	–	1.0±0.1
Model	–	–	–	–	–	81.00	2000	2000	–

- Very small pitch
- Only lower limit of B

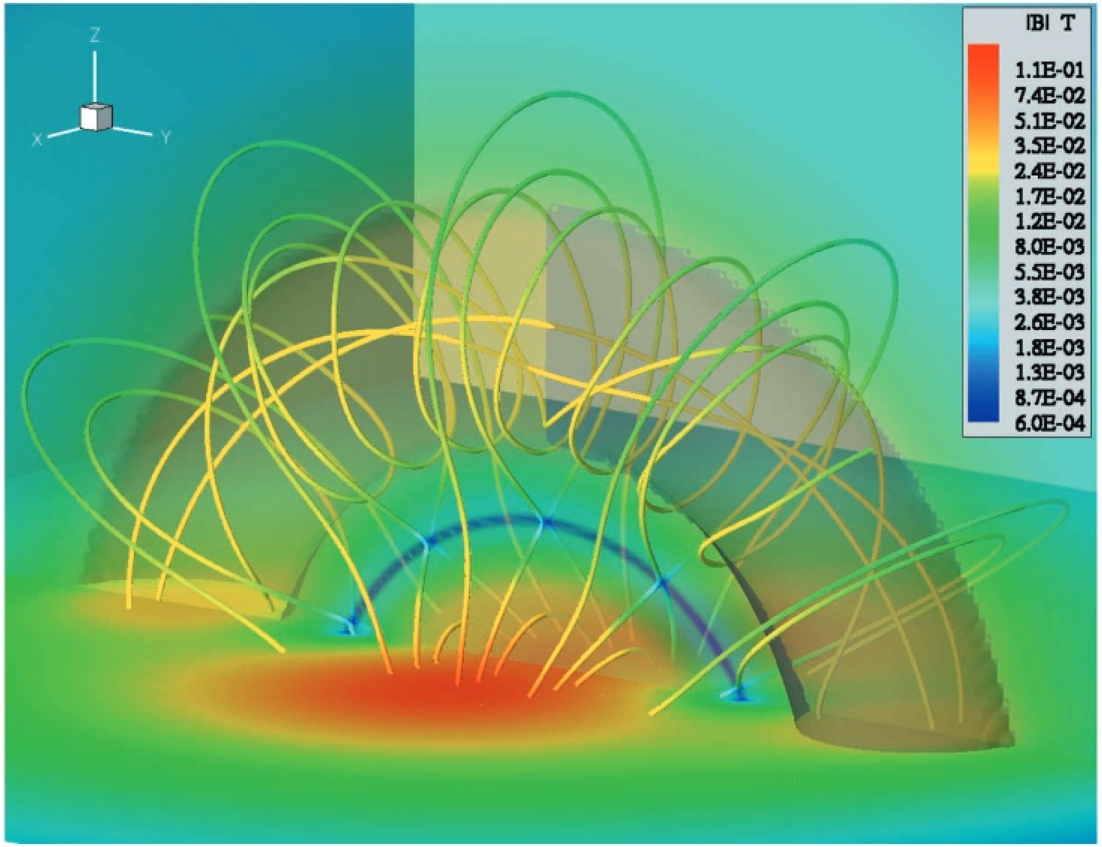
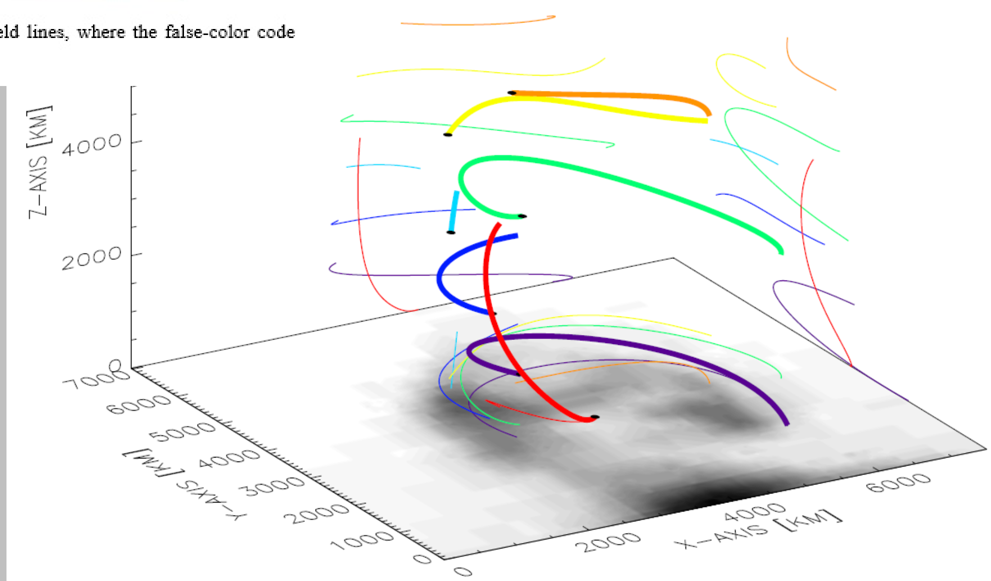


FIG. 1.—Three-dimensional view of the magnetic field configuration for the initial state. The solid lines are magnetic field lines, where the false-color code visualizes the magnetic field strength in units of tesla. The surface shaded in gray is an isosurface of $B_z = 0$.

Roussev et al. 2003, ApJ 588, 45



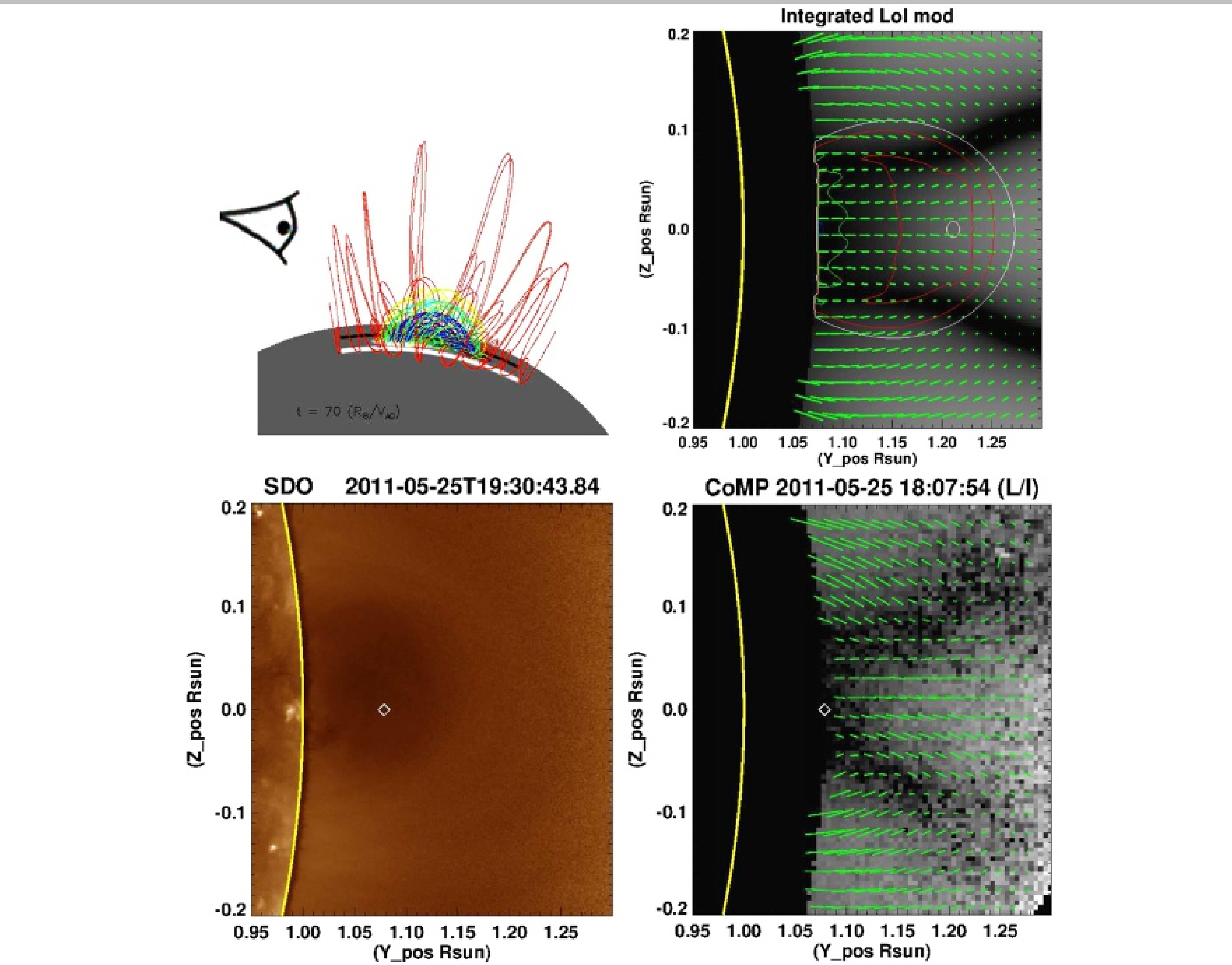


Figure 4. Top row: flux-rope field lines (left) and model linear polarization integrated along the line of sight with the contours showing the current density in the simulations (right). Bottom row: cavity observed by *SDO*/AIA 193 Å (left) and CoMP-observed linear polarization (right). The white diamonds show the center of the cavity seen on AIA images.

Bak-Steslicka et al. 2013, ApJ 770, 28L

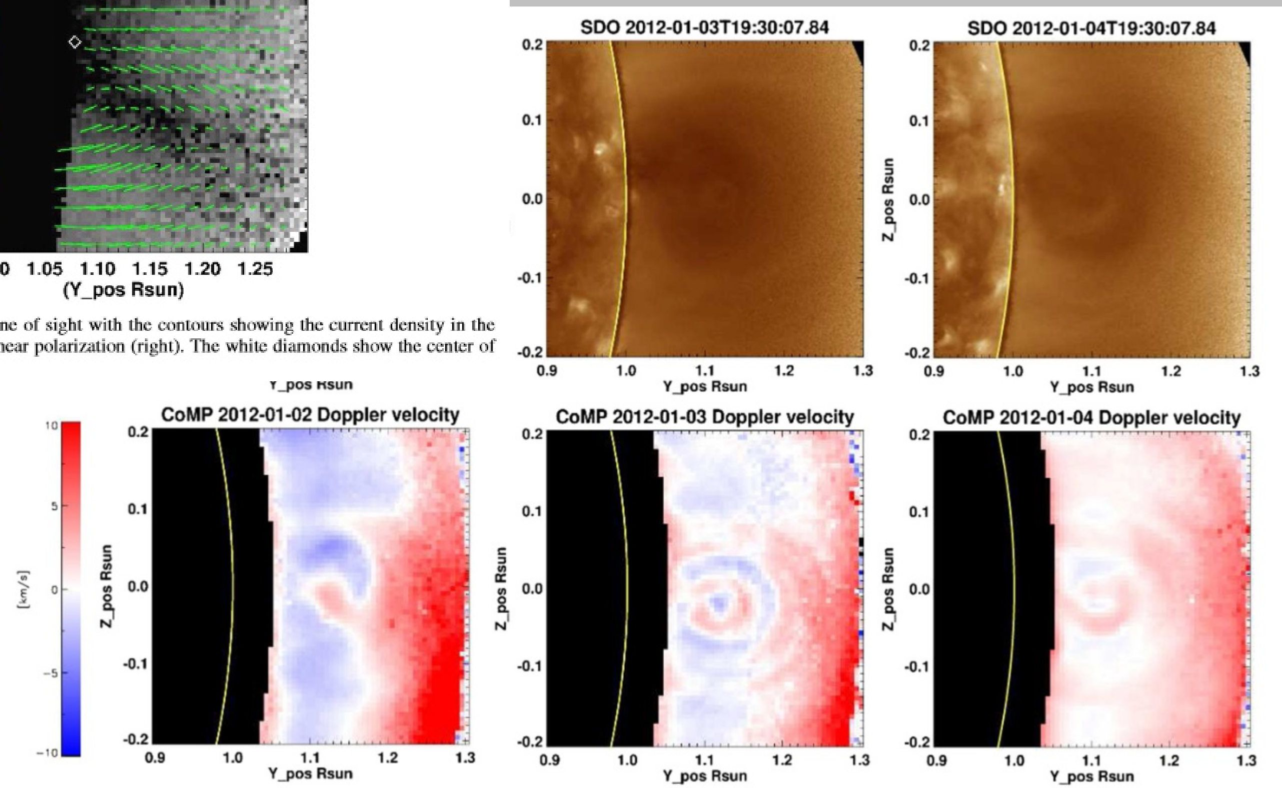


Figure 5. Top row: cavities observed by *SDO*/AIA 193 Å on 2012 January 2–4. Bottom row: Doppler velocity from CoMP observations for the same cavities corrected for solar rotation. The COMP Doppler velocity data are available along with the linear polarization at http://mlso.hao.ucar.edu/.

Conclusions

- Trajectories of knots number 1-6 show highly twisted magnetic flux tube
- Our results show relatively small curvature radius (2000 km)
- A similar value for the curvature radius (r_c =1700 km) has been reported recently by Martinez Gonzalez et al. (2015).
- The estimated pitch angle (> 80°) was very high, which caused instability in the observed prominence and reconstruction of the prominence structure.
- The observational results of Vrsnak (1991) show that all prominences with θ > 80° are at the onset of an eruption or erupting, hence unstable.
- As it has been reported by Vrsnak (1990) and Mrozek (2011), after the onset of an eruption, the prominence may continue to erupt and disappear, or fail to erupt, increase its height, and stay in another stable configuration.
- In our case, with data extending from 09:52 to 12:11 UT, we observed the change of the prominence configuration, increase of its height, and finally halt of the eruption.
- The total twist was impossible to estimate because we observed only a short part of the knot trajectories.
- We estimated the lower limit of the magnetic field strength to 1-3 G and electric current inside the helix to 1.2 $x10^9$ A.
- These values are low as expected from relatively low spatial velocity of the knots (30 km s^{-1}).
- Applications of our trajectory reconstruction method to other, longer datasets may bring complete 3D reconstruction of magnetic field geometry in prominences.