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Magnetic field structures of solar prominences obtained from spectropolarimetric observations in He I 10830 Å

Y. Hashimoto[1], K. Ichimoto[2], Y. Huang[1], D. Yamasaki[3], S. UeNo[1], D. P. Cabezas[4], H. Shirato[1], and Y. Matsuda[1]

1. Kyoto U., 2. Ritsumeikan U., 3. ISAS/JAXA, 4. ISEE/Nagoya U.

Abstract

Context. The magnetic field of solar prominences is an important quantity that determines their structures and energy balance. Some studies have estimated the magnetic field by spectropolarimetric observations, but the field direction and strength of prominences are discrepant among the studies.

Methods. We performed spectropolarimetric observations in He I 10830 Å with the Domeless Solar Telescope at Hida Observatory. Full Stokes profiles of 8 prominences including both quiescent and active region prominences were obtained, and magnetic fields of each prominence were estimated by the inversion using HAZEL.

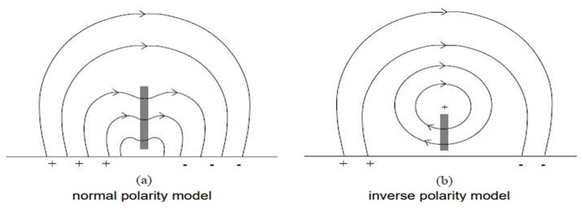
Results. The field strengths of the quiescent prominences were less than 40 G, which is consistent with previous studies. On the other hand, the field strengths of the active region prominences were less than 120 G, which is inconsistent with some of the previous studies which estimated field strengths of on-disk filaments as 100 - 800 G. Our results support the statement by Díaz Baso et al. (2016) that such strong fields come from active regions below the filaments. Furthermore, the magnetic field of one of our prominences is consistent with the field of the corresponding filament observed by Yamasaki et al. (2023) a few days later.

Magnetic Fields of Prominences

The magnetic field is an important quantity for understanding the properties of solar prominences

➢**Configuration**

from van Ballegooijen (2000)



・It is important for understanding eruption mechanism

➢**Energy Balance (Heating Mechanism)**

Magnetic fields determine

・direction of **thermal conduction & mass flow** (Poland&Anzer1971, Hillier&Arregui2019)

・direction and strength of **Alfvén wave energy flux** (Melis+2021, Hashimoto+2023)

Observation and Inversions

Step1 : Observation

・Spectropolarimeter on Domeless Solar Telescope (DST) at Hida obs.

・He I 10830 Å（2nd order, sampling～0.03 Å）

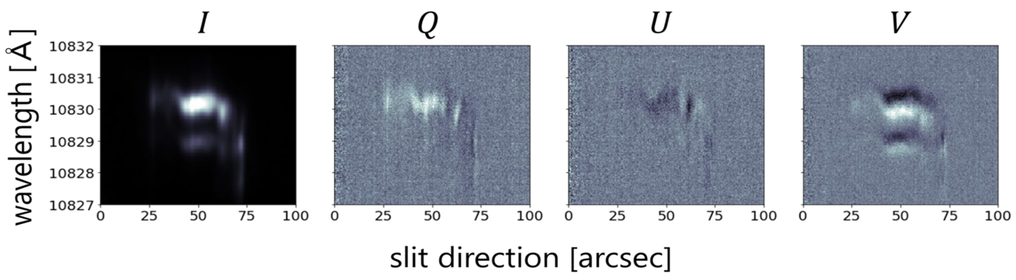
・5 quiescent, 2 active region, and 1 prominence on plage

・slit parallel to the limb, slit width 0.10 mm (～0.64”)

・exposure 30-60 ms (integrate 80-100 images w/ waveplate 1-1.5 sec/rot)

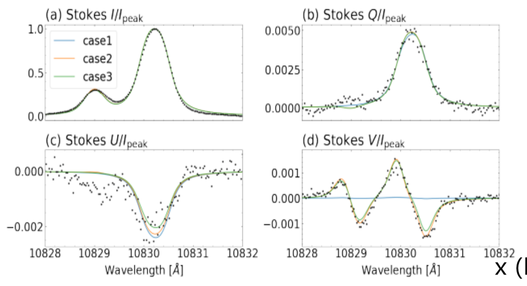
・polarimetric sensitivity ~10^{-3} (to the max. intensity in a prominence)

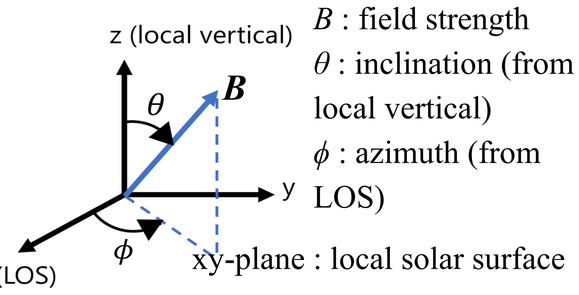
Step2 : Derivation of Stokes Spectrum



Step3 : Estimation of Magnetic Fields

・Inversion using HAZEL (Asensio Ramos+2008)





B : field strength

θ : inclination (from local vertical)

ϕ : azimuth (from LOS)

xy-plane : local solar surface

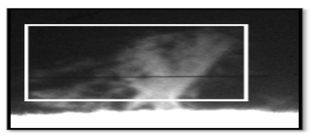
Two solutions (green and orange lines) are possible due to van Vleck ambiguity (e.g. Orozco Suárez+2014)

・quasi-horizontal solution : $54.74^\circ < \theta < 125.26^\circ$

・quasi-vertical solution : θ otherwise

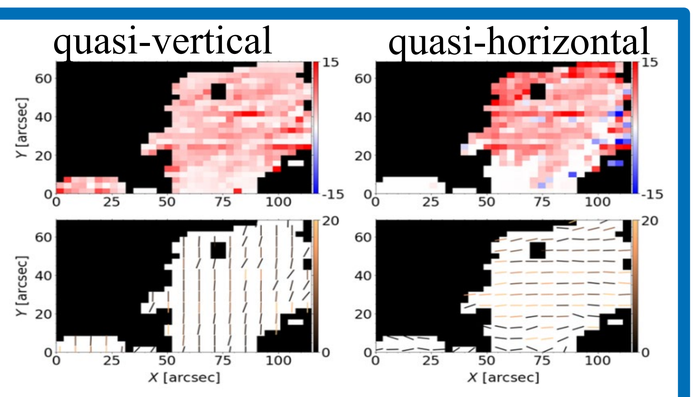
Results

➢**Quiescent Prominence (2022/05/03)**

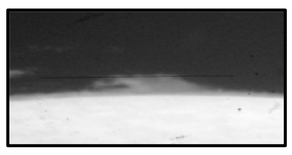


LOS field [G]

POS field [G]

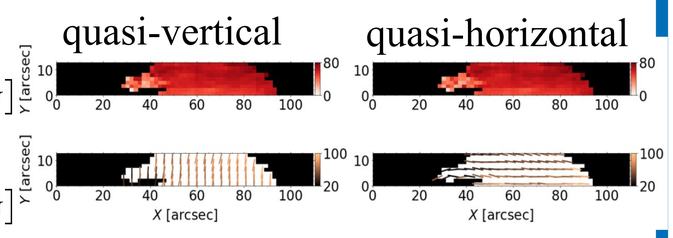


➢**Active Region Prominence (2022/04/30 AR12993)**



LOS field [G]

POS field [G]



➢**Summary of Field Strength**

ID	Type[a]	h/v[b]	Field Strength [G]
1	QS	h	4-31
		v	1-17
2	QS	h	0-94[c]
		v	1-21
3	QS	h	1-27
		v	1-9
4	QS	h	11-18
		v	3-30

ID	Type	h/v	Field Strength [G]
5	QS	h	2-9
		v	2-9
6	AR	h	40-104
		v	50-112
7	AR	h	20-81
		v	32-198[d]
8	Plage	h	13-248
		v	10-47

a. QS:Quiescent, AR:Active region

b. h:quasi-horizontal solution, v:quasi-vertical solution

c. less than 40 G in most region of QS

d. less than 80 G in most region of AR

Discussion & Conclusion

➢**Field Strength**

●Quiescent prominence : B < 40 G

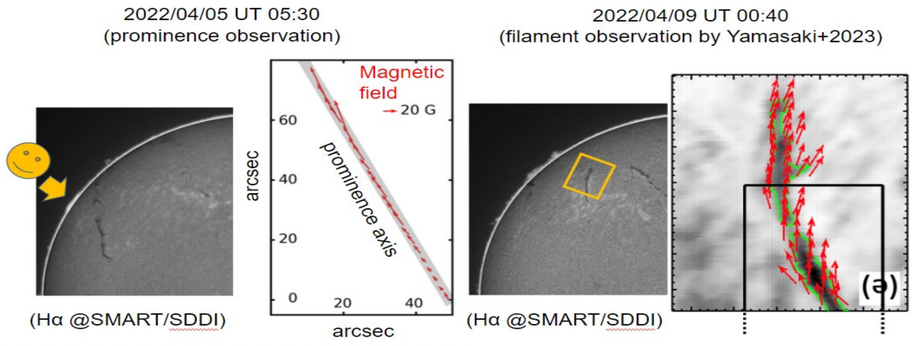
⇒ consistent with previous studies (e.g. Trujillo Bueno+2002, Orozco Suárez+2014)

●Active region prominence : B < 120 G

⇒ weaker than previous studies’ results (100-800 G) (filament observations by Kuckein+2009, Sasso+2011)

⇒ strong fields may come from active regions below the filaments (Díaz Baso+2016)

➢**Comparison with Corresponding Dark Filament**



・25 G (mean value)
・along prominence axis

・26 G (mean value)
・along prominence axis

(quasi-horizontal solution is shown) **consistent result**