3^{rd} Semester Report

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Ph.D. Thesis topic:

“Nonlinearities and Stochastic Perturbations in Dynamo Models”

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- # Introduction

The Sun's' magnetic field is generated by magnetohydrodynamical induction process, or a combination of processes taking place primarily in the solar convection zone. On small spatial scales, convection is believed to continuously process and replenish the photospheric magnetic field, through a local dynamo mechanism that is statistically stationary and does not produce net signed flux (Lemerle A. C.-D., 2015).

These processes are modeled by the surface flux transport equation, which describes the evolution of the radial component of the magnetic field B_r on the solar surface, the equation is the r-component of the MHD induction equation at $r = R_\odot$ under the assumption that the field at the surface is purely vertical, augmented by a source term for B_r, and flux removal term, S and D respectively (Jiang J. H., 2014).

Surface flux transport (SFT) models have been developed and used for decades (DeVore, 1984, Wang, 1989, Van Ballegooijen, 1998, Schrijver, 2002, Baumann, 2004, Jiang J. I., 2010), as SFT developed, it was used for forecast the polar magnetic field that serves as seed for the next solar cycle (Jiang J. W., 2018, Petrovay, 2010).

- # Description of research work

During this semester, several experiments were run, using the python code that was written in a previous semester to study the polar magnetic field, we ran this code for several parameters (diffusivity, meridional flow velocity, decay term) and several profiles (Dikpati, 2006, Van Ballegooijen, 1998) and (Lemerle A. C., 2017), then using the generated data we plot Butterfly diagram (Figure 1) and contour plots (Figure 2) for different profiles between different parameters (phase dipole moment, reversal of dipole moment, half maximum of dipole moment) and constrained by the observational values from Wilcox Solar observatory (WSO), Sunspot number (SSN) and axial dipole moment (See table 1, 2).

Cycle#	min.time	WSO at min	WSO max.	WSO max.time	[6]	reversal time	[8]
21	1976.206	-9999	-131.753	1985.79	9.584	1980.708	4.502
22	1986.707	-131.0737	106.417	1993.455	6.748	1990.623	3.916
23	1996.624	97.9358	-65.3589	2004.624	8	2000.708	4.084
24	2008.958	-54.63141	62.82371	2017.958	9	2013.79	4.832

Table 1: WSO data, Column 6 and 8 are the WSO max.time since cycle min and WSO reversal time since cycle min. respectively.

Cycle#	min.time	WSO at min	WSO max.	WSO max.time	[6]	reversal time	[8]
21	1976.206	-9999	4.23	1984.29	8.084	1979.623	3.417
22	1986.707	4	3.96	1992.124	5.417	1989.98	3.273
23	1996.624	1.95	3.1	2003.204	6.58	1999.958	3.334
24	2008.958	1.34	1.93	2017.958	9	2012.708	3.75

Table 2: Dipole moment values, Column 6 and 8 are the p max.time since cycle min and p reversal time since cycle min.

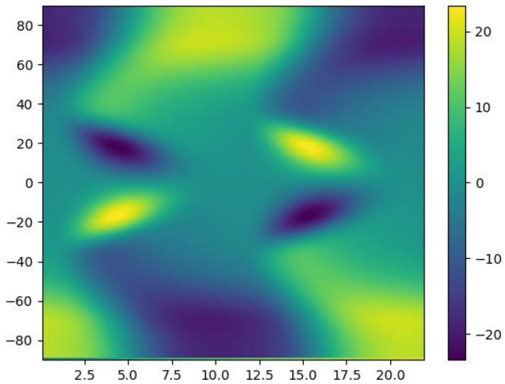

Figure 1: Simulated Butterfly diagram for the (Van Ballegooijen, 1998) meridional flow profile where velocity = 5, diffusivity =500, and decay term = 8

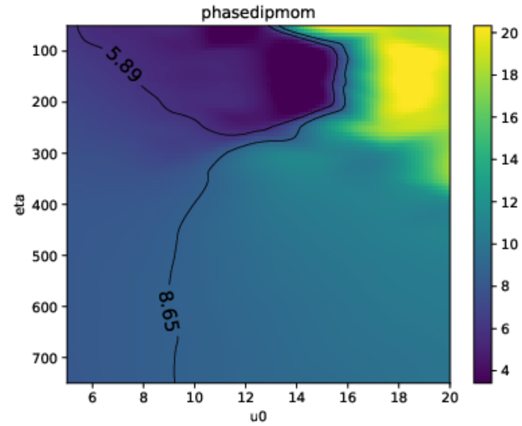

Figure 2: Phase of the dipole moment contours for the (Van Ballegooijen, 1998) meridional flow profile as a function of meridional velocity and diffusivity, for decay term = 7

Publications

- **Talafha, M. H.,** Al-Wardat, M. A., and Ershaidat, N. M. (2018). A Study of the Abundance of Low-Z Elements in the Sun During its Whole Predicted Life. Astrophysical Bulletin, 73(2), 235-240.
- Suleiman N., Al-wardat M., **Talafha M.,** AL-Ameryeen H., Toth V. (2018). Astronomy education in Jordan. Proceedings of the International Astronomical Union, accepted in October 2018.
- **Talafha, M. H**. and Petrovay, K. (2019). Optimization of Surface Flux Transport Models for the Solar Polar Magnetic Field, In preparation: writing results and discussion.

Courses

- FIZ/2/022 - Experimental methods of nuclear physics – Dr. Kai Zuber
- FIZ/2/031E - Advanced informatics in astronomy I. - Dr. Forgácsné Dajka Emese
- FIZ/2/071E - Physics of the solar atmosphere - Dr. Petrovay Kristóf

Attended Conferences

- August 20-31, 2018., Vienna, Austria, XXX IAU General Assembly, Poster entitled "Astronomy education in Jordan", Nofoz Suleiman, Viktor Toth, Mashhoor Al-wardat**, Mohammed Talafha**.
- September 10 – 13, 2018., Granada, Spain, HINODE -12: The Many Suns, Poster entitled "Optimization of surface flux transport models for the solar polar magnetic field", **Mohammed Talafha** and Kristof Petrovay.
- November 26 - 28, 2018., Dresden, Germany, MHD Days and GdRI Dynamo Meeting, Poster entitled "Optimization of surface flux transport models for the solar polar magnetic field", **Mohammed Talafha** and Kristof Petrovay.

Conferences in Future

- May 6 – 10, 2019, Hvar, Croatia, 2nd China-Europe Solar Physics Meeting (CESPM 2019), abstract submitted "Optimization of surface flux transport models for the solar polar magnetic field", "Global dipole moment study using optimized surface flux transportation model".

- 30 June - 6 July, 2019, Copiapo, Chile, IAU Symposium 354: Solar and Stellar Magnetic Fields: Origins and Manifestations, abstract submitted “Global dipole moment study using optimized surface flux transportation model”.

- **Awards**

- ELTE Talent Support scholarship – Budapest, Hungary, Autumn Semester 2018/2019.

- **References**

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DeVore, C. R. (1984). The concentration of the large-scale solar magnetic field by a meridional surface flow. *Solar physics*, 92(1-2), 1-14.

Dikpati, M. D. (2006). Predicting the strength of solar cycle 24 using a flux-transport dynamo-based tool. *Geophysical research letters,*, 33(5).

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Petrovay, K. (2010). Solar cycle prediction. *Living Reviews in Solar Physics*, 7(1), 6.

Schrijver, C. J. (2002). What is missing from our understanding of long-term solar and heliospheric activity? *The Astrophysical Journal*, 577(2), 1006.

Talafha, M. H.-W. (2018). A Study of the Abundance of Low-Z Elements in the Sun During its Whole Predicted Life. *Astrophysical Bulletin*, 73(2), 235-240.

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Wang, Y. M. (1989). Evolution of the sun's polar fields during sunspot cycle 21-Poleward surges and long-term behavior. *The Astrophysical Journal*, 347, 529-539.