

# Curso de postgrado

## Plasmas espaciales. Pasado, presente y futuro.

10 UD

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### Requisitos

Nociones de física de plasmas

### Objetivo del curso

A través de la lectura y presentación de artículos científicos, introducir a los estudiantes en las temáticas de plasmas espaciales, las preguntas científicas relevantes, los avances desde la segunda mitad del siglo XX en adelante, y las preguntas abiertas en el área.

### Programa

1. Corona solar y generación del viento solar
2. Aceleración y calentamiento del viento solar.
3. Interacciones onda-partícula en el viento solar.
4. Ondas y turbulencia magnetohidrodinámica en la heliósfera.
5. Interacción del viento solar con magnetósferas planetarias.

### Clases y horario

Una o dos veces por semana (dependiendo de la cantidad de inscritos) en el Departamento de Física de la Facultad de Ciencias. El curso se realizará con un mínimo de dos estudiantes. Horario por definir durante julio de 2018.

### Modalidad del curso

Los estudiantes deberán leer artículos y preparar una presentación semana por medio. La nota final del curso corresponderá al promedio simple de todas las presentaciones (unos 7 u 8 artículos por estudiante).

### Bibliografía propuesta

1. Alfvén, H. Existence of Electromagnetic-Hydrodynamic Waves. *Nature* 150, 405–406 (1942).
2. Alfvén, H. Magneto-hydrodynamic waves and sunspots. I, II. *Monthly Notices of the Royal Astronomical Society* 105, 3 (1945).

3. Alfvén, H. Magneto hydrodynamic waves, and the heating of the solar corona. *Monthly Notices of the Royal Astronomical Society* 107, 211 (1947).
4. Parker, E. N. Hydromagnetic Dynamo Models. *The Astrophysical Journal* 122, 293 (1955).
5. Chew, G. F., Goldberger, M. L. & Low, F. E. The Boltzmann equation and the one-fluid hydromagnetic equations in the absence of particle collisions. *Proc. R. Soc. Lond. A* 236, 112–118 (1956).
6. Parker, E. Sweet's mechanism for merging magnetic fields in conducting fluids. (1957). Available at: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/JZ062i004p00509>. (Accessed: 10th July 2018)
7. Dungey, J. W. Interplanetary Magnetic Field and the Auroral Zones. *Phys. Rev. Lett.* 6, 47–48 (1961).
8. Axford, W. I. The interaction between the solar wind and the Earth's magnetosphere. *Journal of Geophysical Research* 67, 3791–3796 (1962).
9. Kraichnan, R. H. Inertial-Range Spectrum of Hydromagnetic Turbulence. *The Physics of Fluids* 8, 1385–1387 (1965).
10. Coppi, B., Rosenbluth, M. N. & Sagdeev, R. Z. Instabilities due to Temperature Gradients in Complex Magnetic Field Configurations. *The Physics of Fluids* 10, 582–587 (1967).
11. Eviatar, A. & Schulz, M. Ion-temperature anisotropies and the structure of the solar wind. *Planetary and Space Science* 18, 321–332 (1970).
12. Belcher, J. W. & Davis, L. Large-amplitude Alfvén waves in the interplanetary medium, 2. *Journal of Geophysical Research* 76, 3534–3563 (1971).
13. Lemaire, J. & Scherer, M. Kinetic models of the solar wind. *Journal of Geophysical Research* 76, 7479–7490 (1971).
14. Lemaire, J. & Scherer, M. Simple Model for an Ion-Exosphere in an Open Magnetic Field. *The Physics of Fluids* 14, 1683–1694 (1971).
15. Matthaeus, W. H. & Goldstein, M. L. Measurement of the rugged invariants of magnetohydrodynamic turbulence in the solar wind. *Journal of Geophysical Research: Space Physics* 87, 6011–6028 (1982).
16. Tsyganenko, N. A. On the convective mechanism for formation of the plasma sheet in the magnetospheric tail. *Planetary and Space Science* 30, 1007–1012 (1982).
17. Draine, B. T., Roberge, W. G. & Dalgarno, A. Magnetohydrodynamic shock waves in molecular clouds. *The Astrophysical Journal* 264, 485–507 (1983).
18. Shebalin, J. V., Matthaeus, W. H. & Montgomery, D. Anisotropy in MHD turbulence due to a mean magnetic field. *Journal of Plasma Physics* 29, 525–547 (1983).

- 19.Zank, G. P. & Matthaeus, W. H. The equations of reduced magnetohydrodynamics. *Journal of Plasma Physics* 48, 85–100 (1992).
- 20.Biskamp, D. *Nonlinear Magnetohydrodynamics* by Dieter Biskamp. Cambridge Core (1993).
- 21.Southwood, D. J. & Kivelson, M. G. Mirror instability: 1. Physical mechanism of linear instability. *Journal of Geophysical Research: Space Physics* 98, 9181–9187 (1993).
- 22.Gonzalez, W. D. et al. What is a geomagnetic storm? *Journal of Geophysical Research: Space Physics* 99, 5771–5792 (1994).
- 23.Goldreich, P. & Sridhar, S. Toward a theory of interstellar turbulence. 2: Strong alfvenic turbulence. *The Astrophysical Journal* 438, 763–775 (1995).
- 24.Lazarian, A. & Vishniac, E. T. Reconnection in a Weakly Stochastic Field. *ApJ* 517, 700 (1999).
- 25.Galtier, S., Nazarenko, S. V., Newell, A. C. & Pouquet, A. A weak turbulence theory for incompressible magnetohydrodynamics. *Journal of Plasma Physics* 63, 447–488 (2000).
- 26.Isenberg, P. A. Heating of Coronal Holes and Generation of the Solar Wind by Ion-Cyclotron Resonance. *Space Science Reviews* 95, 119–131 (2001).
- 27.Pierrard, V., Issautier, K., Meyer-Vernet, N. & Lemaire, J. Collisionless model of the solar wind in a spiral magnetic field. *Geophysical Research Letters* 28, 223–226 (2001).
- 28.Reeves, G. D., McAdams, K. L., Friedel, R. H. W. & O'Brien, T. P. Acceleration and loss of relativistic electrons during geomagnetic storms. *Geophysical Research Letters* 30, (2003).
- 29.Bruno, R. & Carbone, V. The Solar Wind as a Turbulence Laboratory | SpringerLink. (2005). Available at: <https://link.springer.com/article/10.12942/lrsp-2005-4>. (Accessed: 10th July 2018)
- 30.Howes, G. G. et al. Astrophysical Gyrokinetics: Basic Equations and Linear Theory. *ApJ* 651, 590 (2006).
- 31.Marsch, E. Kinetic Physics of the Solar Corona and Solar Wind. *Living Rev. Sol. Phys.* 3, 1 (2006).
- 32.Isenberg, P. A. & Vasquez, B. J. Preferential Perpendicular Heating of Coronal Hole Minor Ions by the Fermi Mechanism. *ApJ* 668, 546 (2007).
- 33.Howes, G. G. et al. Kinetic Simulations of Magnetized Turbulence in Astrophysical Plasmas. *Phys. Rev. Lett.* 100, 065004 (2008).
- 34.McComas, D. J. et al. Weaker solar wind from the polar coronal holes and the whole Sun. *Geophysical Research Letters* 35, (2008).
- 35.Bale, S. D. et al. Magnetic Fluctuation Power Near Proton Temperature Anisotropy Instability Thresholds in the Solar Wind. *Phys. Rev. Lett.* 103, 211101 (2009).
- 36.Schekochihin, A. A. et al. Astrophysical Gyrokinetics: Kinetic and Fluid Turbulent Cascades in

Magnetized Weakly Collisional Plasmas. *ApJS* 182, 310 (2009).

37. Wilson, L. B. et al. Low-frequency whistler waves and shocklets observed at quasi-perpendicular interplanetary shocks. *Journal of Geophysical Research: Space Physics* 114, (2009).

38. Reeves, G. D. et al. On the relationship between relativistic electron flux and solar wind velocity: Paulikas and Blake revisited. *Journal of Geophysical Research: Space Physics* 116, (2011).

39. Chandran, B. D. G. et al. Stochastic Heating, Differential Flow, and the Alpha-to-proton Temperature Ratio in the Solar Wind. *ApJ* 776, 45 (2013).

40. Paulikas, G. A. & Blake, J. B. Effects of the Solar Wind on Magnetospheric Dynamics: Energetic Electrons at the Synchronous Orbit. in *Quantitative Modeling of Magnetospheric Processes 180–202* (American Geophysical Union (AGU), 2013). doi:10.1029/GM021p0180

41. Cranmer, S. R. Ensemble Simulations of Proton Heating in the Solar Wind via Turbulence and Ion Cyclotron Resonance. *ApJS* 213, 16 (2014).

42. Denton, M. H. et al. The Evolution of the Plasma Sheet Ion Composition: Storms and Recoveries. *Journal of Geophysical Research: Space Physics* 122, 12,040-12,054 (2017).

43. Gershman, D. J. et al. Wave-particle energy exchange directly observed in a kinetic Alfvén-branch wave. *Nature Communications* 8, 14719 (2017).