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Institut für Sonnenphysik (KIS)

• **Course title**: Experimental Astrophysics I: remote sensing

• **Semester**: Winter Semester 2024/2025

• **Lecturers**:

Dr. Juan Manuel Borrero: `borrero@leibniz-kis.de`
Dr. Ivan Milić: `milic@leibniz-kis.de`

• **Target audience**: Masters' but open to Bachelors.

• **Language**: English.

• **Course description**:

Due to the fact that we cannot directly measure the physical properties of astrophysical bodies, all our quantitative knowledge about the Universe is based on the interpretation of the observed light emitted by these objects (i.e. remote sensing). In this course, we will focus on:

1. the generation and propagation of light in the Solar and stellar atmospheres;
2. observations of solar and stellar spectra and their polarization;
3. methods for inferring the physical characteristics of the object (temperature, chemical composition, magnetic field, etc.) from the light we are receiving.

To this end, we will combine concepts from electromagnetism, optics, quantum mechanics, and probabilistic inference. Besides the astrophysical applications, the course will equip the students with tools they can use in their careers, both in science and in other areas related to STEM. The lectures will be reinforced with hands-on exercises in python with a brief critical introduction to python programming.

The following topics will be addressed in lectures:

1. Introduction to telescopes and spectral discriminators: spectrographs and filtergraphs
2. Basics of spectra formation: absorption, emission, and scattering in spectral lines and the continuum
3. Zeeman effect and polarization due to the magnetic field.
4. Polarimetry: anisotropy as sources of polarization, polarimetric modulation and demodulation.
5. Parameter inference: Model fitting, probabilistic inference, uncertainty estimation

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Practical exercises will include problem solving, use of scientific software, participation in remote observing with Europe's largest solar telescope GREGOR (Tenerife, Spain) or in-person observations at the Schauinsland observatory, as well as analysis of data from the Hinode satellite.

• **Minimum requirements**: 2 years of undergraduate physics with electromagnetism.

• **Recommended requirements**: introductory quantum/atomic physics, mathematical methods for physicists (Fourier transforms, linear algebra, matrix diagonalization, eigenvalues), and introductory programming (python).

• **Hours**: 4 hours / week (2 theory + 2 excersices)

• **Course webpage**: `https://gitlab.leibniz-kis.de/borrero/experimental_astrophysics`

• **Bibliography**:

1. Introduction to spectropolarimetry. Del Toro Iniesta. Cambridge Univ. Press. 2003
2. The Sun: an introduction. M. Stix, SpringerLink, 2003
3. Inverse problems in Astronomy, I.J.D. Craig & J.C. Brown, CRC Press, 1986
4. Numerical Recipes, the Art of Scientific Programming, 3rd edition, C. Press et al., Cambridge University Press, 2007
5. Observation and analysis of stellar photospheres, 4th edition. D. F. Gray. Cambridge Univ. Press. 2021.