



STELLAR MAGNETIC ACTIVITY

(PAP351)

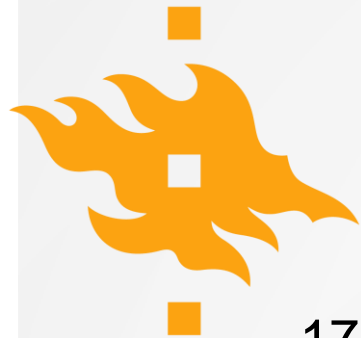
Lecture 1, 17.1.2024

Thomas Hackman

GENERAL INFORMATION



- **Stellar magnetic activity (SMA, 5 cr), periods 3-4/2024**
- **Lectures on Wednesdays 2:15 PM–4:00 PM in Physicum D117**
- **Exercises approx. every 2nd week after the lectures, first session February 7.**
- **Assistant teacher András Haris-Kiss.**
- **Exam in May at the end of the course.**
- **Course home page:
<https://wiki.helsinki.fi/xwiki/bin/view/SMA>**



PROGRAMME (CHANGES STILL POSSIBLE)

17/1/2024 Introduction: Stellar magnetic fields

24/1/2024 Sunspots

31/1/2024 Manifestations of stellar magnetic activity and classification of active stars

7/2/2024 Methods of observing starspots

14/2/2024 Stellar spot activity:
Observational results and conclusions

21/2/2024 Basic MHD concepts

28/2/2024 Solar and stellar dynamos I:
Basic concepts

3/3/2024 Solar and stellar dynamos II:
models

20/3/2024 Solar chromosphere and corona

27/3/2024 Solar wind interaction with Earth's magnetosphere

10/4/2024 Magnetic activity and exoplanets

17/4/2024 Open questions in stellar magnetic activity

24/4/2024 Conclusion



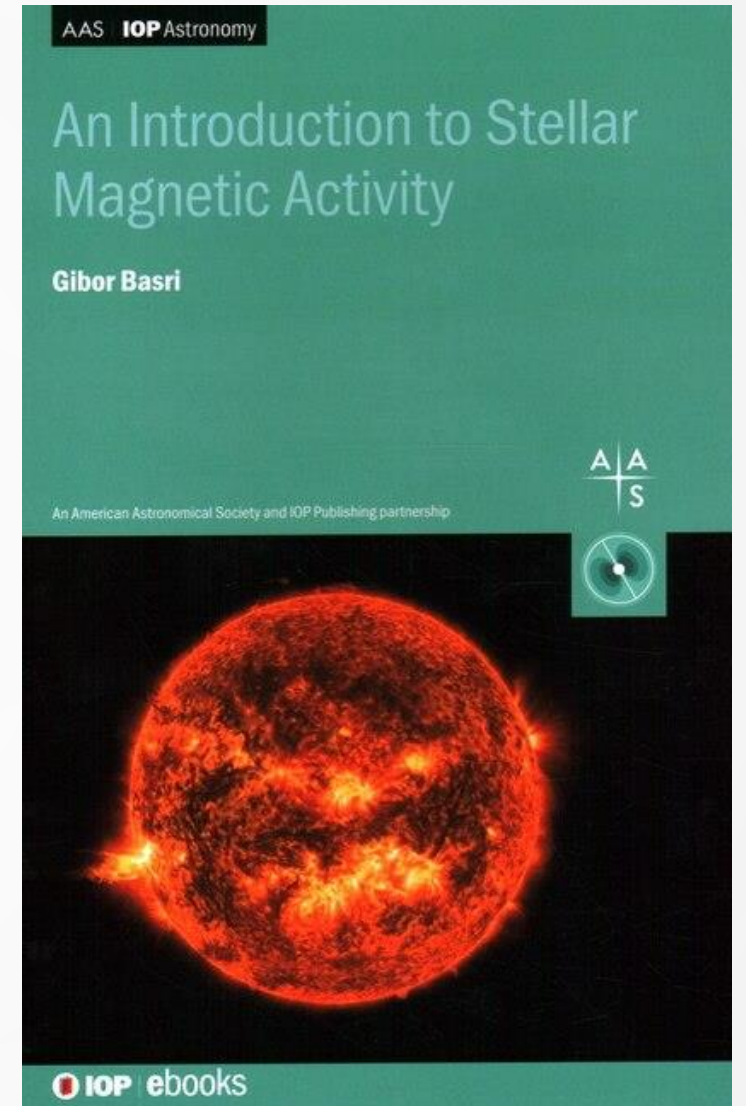
AIM OF THE COURSE

- To provide a basis for understanding **stellar magnetic activity**
- In particular:
 - **Theory**
 - **Modelling**
 - **Observations**
- The lecturers aim at providing insight into the newest results in the field



LITTERATURE

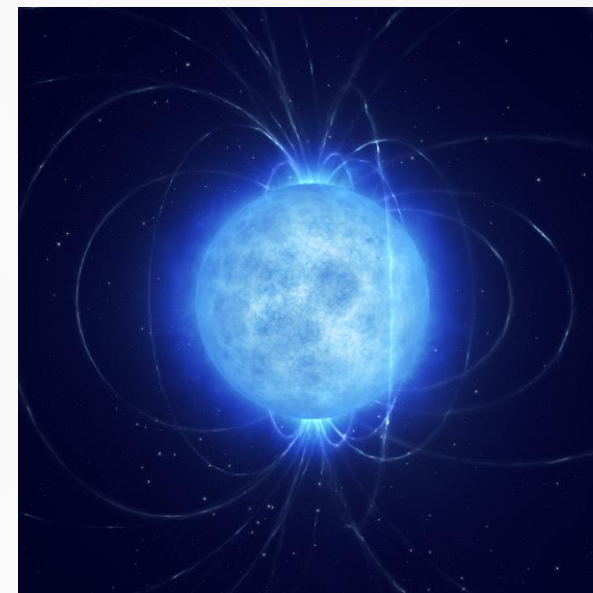
- Text Book: Gibor Basri, ***An Introduction to Stellar Magnetic Activity***
- Scientific articles, e.g.:
 - Strassmeier, K.G., 2009, A&A Rev 17, 251
 - Ossendrijver, M, 2003, A&A Rev. 11, 287
 - Living reviews
- PhD theses: Heidi Korhonen (UO 2002), Thomas Hackman, (UH 2004), Petri Käpylä (UH 2006), Jyri Lehtinen (UH 2016), Elizabeth Cole (UH 2017), Teemu Willamo (UH2022)





1. STELLAR MAGNETIC FIELDS: HOT STARS

- Early type magnetic stars:
 - Radiative envelope
 - Often strong stable magnetic fields
 - Ap-stars: Chemically peculiar stars
 - Magnetic white dwarfs
 - Neutron stars: Pulsars, magnetars
 - ~ static magnetic fields => not the topic of this course



Magnetic white dwarf.
Credit: ESO / Calçada.



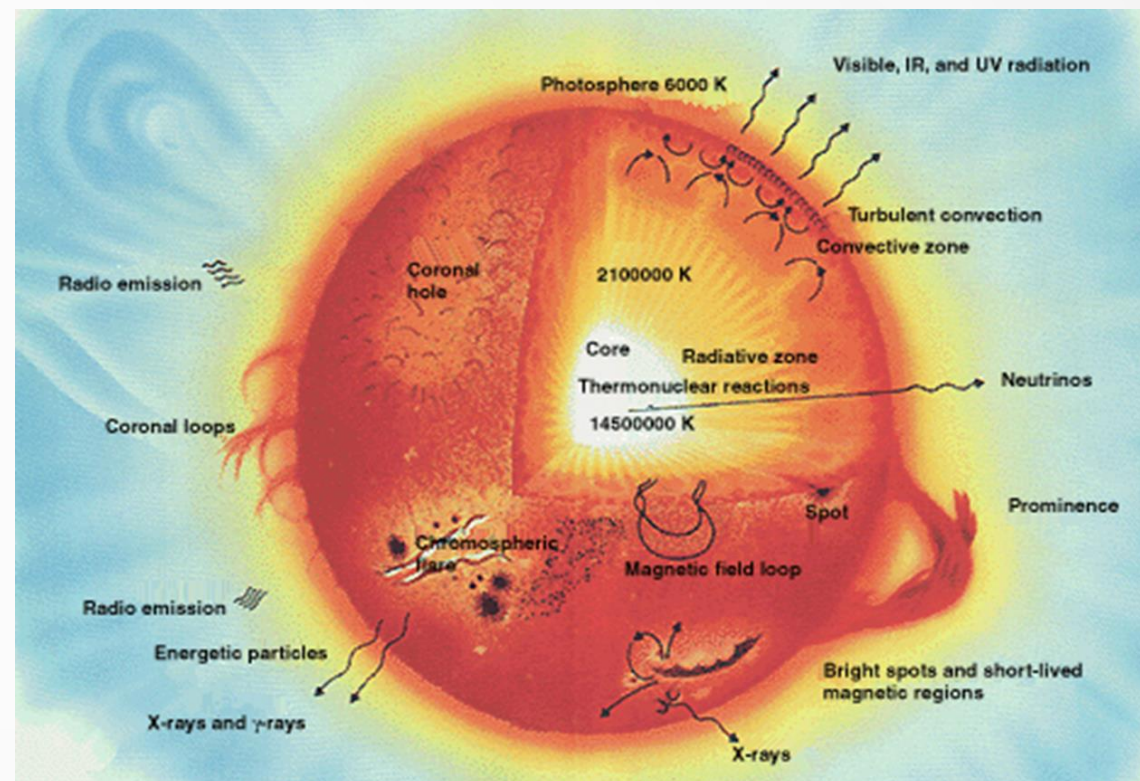
2. STELLAR MAGNETIC FIELDS: COOL STARS

- Magnetically active stars
 - Late type stars \Leftrightarrow convective envelope
 - Activity with magnetic origin:
 - Starspots + bright regions
 - Surface magnetic fields
 - Chromospheric and coronal activity
 - Activity level related to spectral class and rotation velocity
 - Long- and short-term variability \Leftrightarrow dynamo



2.1 MANIFESTATIONS OF STELLAR ACTIVITY

- Spots
- Bright surface phenomena: Faculae ...
- Ca II H&K, H α -emission (chromosphere)
- UV-radiation (transition region, corona)
- X-rays (corona)
- Eruptions: Prominences, flare, CMEs
- Indirect effects (in the case of the Sun)
 - Disturbances in the geomagnetic fields, “space weather”
 - Abundance of radionuclides





2.2 SHORT HISTORY OF OBSERVING SUN'S MAGNETIC ACTIVITY

- Sunspot observations by the **Chinese** from about 2000 years ago
- 17th century: Telescopic observations of sunspots (**Galilei** and others)
- Systematic sunspot observation started in the 18th century
- **Schwabe** (1844): 11-year sunspot cycle
- **Carrington** (1859): Connection between flare and magnetic storm
- **Mitchell** (1904) and **Hale** (1908): Connection between sunspots and magnetic fields
- **Hale & Nicholson** (1919, 1925): ~ 22-year magnetic cycle
- **Gleissberg** (1945): 80-120 year long term variability



2.2.1 HISTORICAL SUNSPOTS OBSERVATIONS

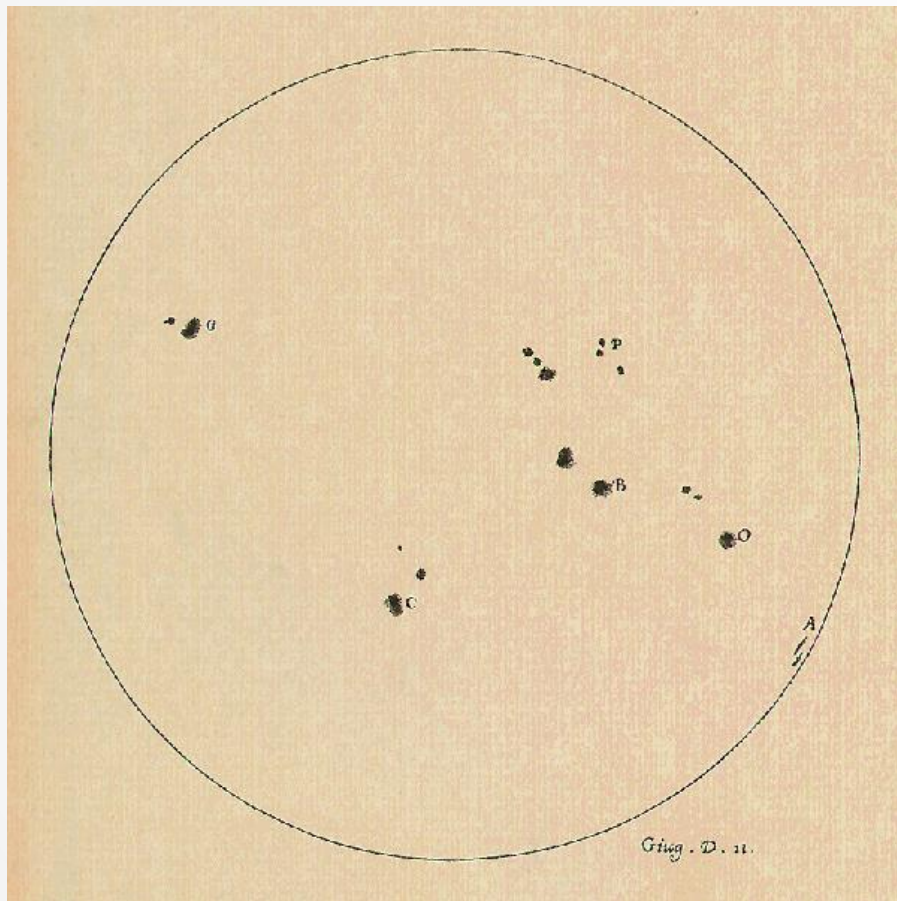


The first sunspot drawing, John of Worcester, ~1128 AD

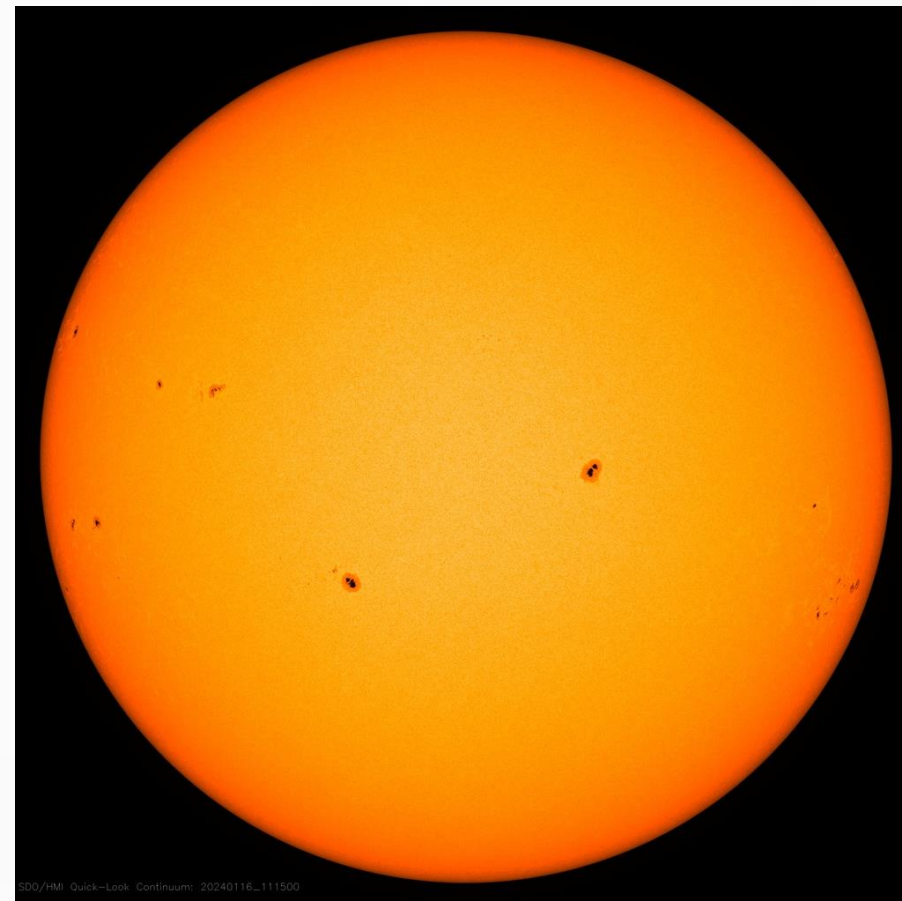


2.2.2 SUNSPOTS OBSERVATIONS BY GALILEI

Galilei, 1612



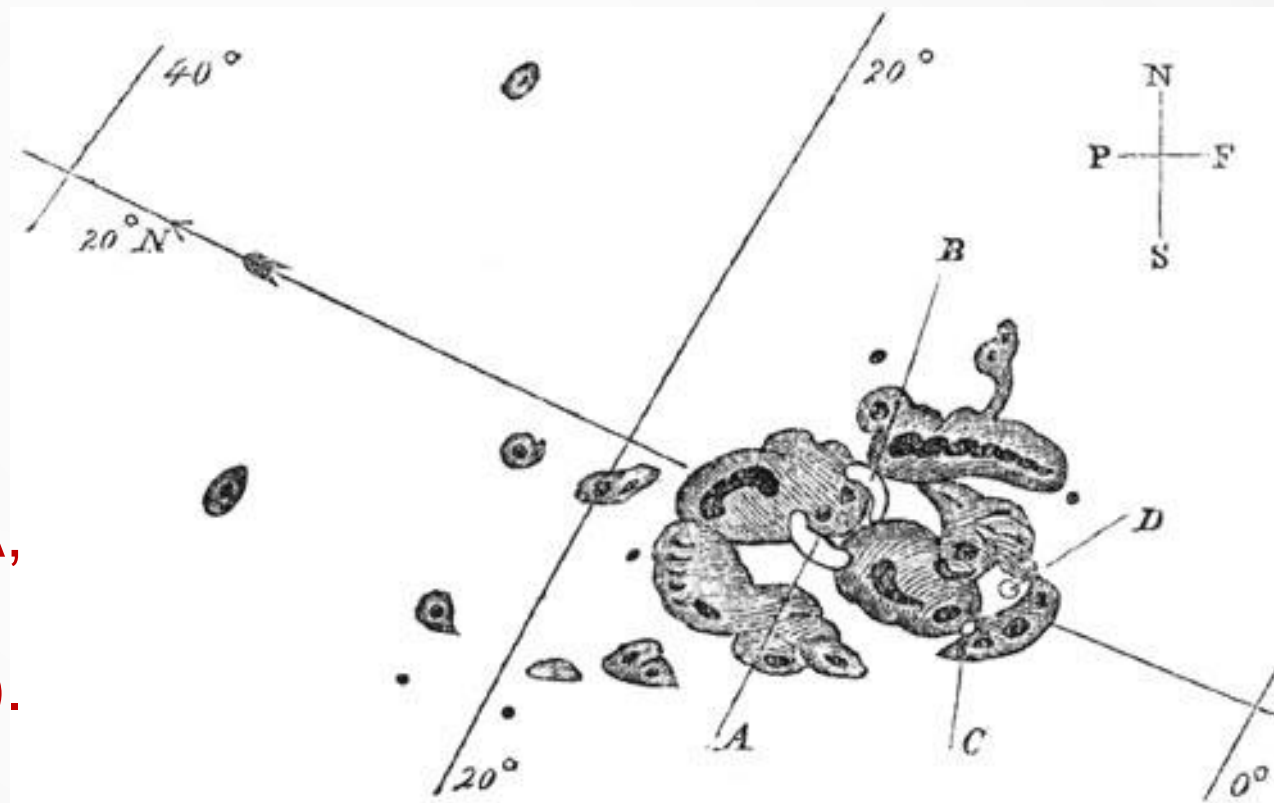
Solar Dynamic Observatory, 1/2024





2.2.3 CARRINGTON EVENT 1859

Sunspots September 1, 1859. A, B, C and D mark positions of bright events (Carrington, 1859).





2.3 MAGNETIC ACTIVITY OF OTHER STARS

- **Luyten** (1930's): Red dwarfs with flares
- **Kron** (1947): The light curve of AR Lac caused by “bright/dark patches”
- **Hoffmeister** (1965) & **Chugainov** (1965): Observations of starspots by photometry
- **Wilson** (1966): Monitoring of stellar Ca II H & K emission
- **Robinson, Gray, Saar** (1980's): Zeeman effect in stars
- **Vogt** et al. (1983, 1987): Doppler images of late type stars
- **Semel** (1989) & **Brown** et al. (1991): Zeeman-Doppler imaging
- **Argiroffi** et al. (2018): Stellar CME