Commission 36: Theory of Stellar Atmospheres

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1. Introduction

Commission 36 covers all the physics of stellar atmospheres. The scientific activity in this large field has been very intense during the last triennium and led to the publication of a large number of papers which makes an exhaustive report practically not feasible. As a consequence we decided to keep the format of the preceding report: first a list of areas of current research, then web links for obtaining further information.


2. Primary research areas 2002–2005

2.1. Physical processes

**General properties** Improved models available to the community. Grids of synthetic fluxes and spectra. Calibrating parameterized models through physical modeling. Calibrating abundance determinations by filter photometry or low-resolution spectroscopy.

**Stationary processes within stellar atmospheres** Convection (granulation) in surface layers, and its effects upon emergent spectra. Interplay between convection and non-radial pulsation. Scales of surface convection in stars in different stages of evolution. Hydrodynamic simulations of entire stellar volumes.


**Magnetic phenomena** Magnetic structures in single and binary stars. Dynamo generation of magnetic fields by convection. Effects by magnetic fields on convective structures. Magnetic cycles at varying activity levels. Polarized radiation, gyrosynchrotron
and X-ray emission. Interpreting Zeeman-Doppler images of stellar surfaces. Hanle effect diagnostics in stellar environments.


**Forbidden lines and maser emission** Molecules in atmospheres of cool giant stars. Effects of fluorescence. Permitted and forbidden lines from shocked atmospheres of pulsating giants. Maser and laser emission from stellar envelopes.


**Molecules** Chromospheric structures and temperature inhomogeneities. Cool molecular constituents in warm stars. Molecular spheres around red giants. Molecular opacities, and non-LTE effects. Role of molecular hydrogen.

### 2.2. Stellar structure

**Structures across stellar disks** Doppler mapping of starspots. Radii and oblateness at different wavelengths for giant stars. Gravitational microlensing to test model atmospheres. Interaction between rotation and pulsation. Doppler tomography of stellar envelopes.

**Stellar coronae** Coronal heating mechanisms (quiescent and flaring). Effects of age and chemical abundance. Multicomponent structure. Coronae in also low-mass stars and brown dwarfs. Diagnostics through X-ray spectroscopy and radio emission.


**Dust, grains, and shells** Formation of stellar dust shells. Grains in the atmospheres of red giants, and in T Tauri stars.

### 2.3. Different classes of objects

**Pulsating stars and asteroseismology** Classically variable stars, and ‘ordinary’ solar-type ones. Inverting observed pressure-mode frequencies into atmospheric structure. Mass-loss mechanisms in pulsating stars. Effects of rapid rotation on pulsation.


Interaction with exoplanets  Effects of planets on the atmospheres of evolved red giants. Characteristics of stars hosting exoplanets.

2.4. Development of techniques

Computational techniques  Parallel (super)computing to simulate convective surface regions, and throughout complete stars. Neural networks and machine-learning algorithms. Preparing for the widely distributed network of computational tools and shared databases being developed for the forthcoming computing infrastructure GRID.

2.5. Applications of stellar atmospheres

Besides their study per se, stars are being used as probes for other astrophysical problems:

Exoplanets  Variable wavelength shifts in stellar spectra serve as diagnostics for radial velocity variations induced by orbiting exoplanets. Atmospheric modeling can indicate which spectral features are suitable as such probes, and which should be avoided due to their sensitivity to intrinsic stellar activity.

Chemical evolution in the Galaxy  How accurately observations of stellar spectral features can be transformed into actual chemical abundances depends sensitively on the sophistication of the stellar model atmospheres.

Kinematics of the Galaxy  Planned space missions intend to measure radial velocities for huge numbers of stars. Model atmospheres are used to identify suitable spectral features for such measurements in different classes of stars.

Galaxies and cosmology  Stars are the main observable component of galaxies, and population synthesis for galaxies utilize model atmospheres to interpret observations. Cosmological origin of the lowest-metallicity stars.
3. Web links for further information

The following collection of links provides introductions and overviews of several significant subfields of the physics of stellar atmospheres.

3.1. Calculating atmospheric models and spectra

ATLAS, SYNTHE, and other model grids
http://kurucz.harvard.edu
MARCS, model grids
http://www.marcs.astro.uu.se
Tuebingen: Stellar atmospheres – grid of models
http://astro.uni-tuebingen.de/groups/stellar
http://astro.uni-tuebingen.de/~rauch/
CCP7 – Collaborative Computational Project
http://ccp7.dur.ac.uk
CLOUDY – photo-ionization simulations
http://www.nublado.org/
MULTI – non-LTE radiative transfer
http://www.astro.uio.no/~matsc/mul22/mul22.html
PANDORA – atmospheric models and spectra
http://cfa-www.harvard.edu/~rloeser/pandora.html
PHOENIX – stellar and planetary atmosphere code
http://www.hs.uni-hamburg.de/EN/For/ThA/phoenix/index.html
STARLINK – theory and modeling resources
http://www.astro.gla.ac.uk/users/norman/star/sc13/sc13.htx
Synthetic spectra overview
http://www.am.ub.es/~carrasco/models/synthetic.html
TLUSTY – model atmospheres
http://tlusty.gsfc.nasa.gov

3.2. Useful links from Research groups or Individual researchers

Vienna: Stellar atmospheres and pulsating stars
Potsdam: Stellar convection
http://www.aip.de/groups/sternphysik/stp/convect_neu.html
M. Asplund: Stellar convection and line formation
http://www.mso.anu.edu.au/~martin
R.F. Stein: Convection simulations & radiation hydrodynamics
http://www.pa.msu.edu/~steinr/research.html#research
D. Dravins: Stellar surface structure
http://www.astro.lu.se/~dainis/HTML/GRANUL.html
A. Collier Cameron: Starspots and magnetic fields on cool stars
D.F. Gray: Stellar rotation, magnetic cycles, velocity fields
http://www.astro.uwo.ca/~dfgray/
J.F. Donati: Magnetic fields of non degenerate stars
http://webast.ast.obs-mip.fr/people/donati/field.html
M.Jardine: Stellar coronal structure
http://star-www.st-and.ac.uk/~mmj/Welcome_research.html

Munich: Programs, Models, Fluxes and synthetic Spectra of the atmospheres of hot stars
http://www.usm.uni-muenchen.de/people/adi/adi.html

S.Jeffery: Stellar model grids, hot stars
http://star.arm.ac.uk/~csj/

P.Stee: Be-star atmospheres and circumstellar envelopes
http://www.obs-nice.fr/stee/Bmodel.html
http://www.obs-nice.fr/stee/simugb.html

J.L.Linsky: Cool stars, stellar chromospheres and coronae
http://jilawww.colorado.edu/~jlinsky/

G.Basri: Brown dwarfs
http://astro.berkeley.edu/~basri/bdwarfs/

Adam Burrows: M dwarfs, brown dwarfs etc model atmospheres
http://zenith.as.arizona.edu/~burrows/

Vienna: Atomic Line Database (VALD)
http://ams.astro.univie.ac.at/vald/

D.Montes et al.: Libraries of stellar spectra
http://www.ucm.es/info/Astrof/spectra.html

R.J.Rutten: Lecture notes: Radiative transfer in stellar atmospheres
http://www.fys.ruu.nl/~rutten/node20.html

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