MODERN DEVELOPMENTS IN SOLAR AND STELLAR SPECTROSCOPY
Lectures at the Astronomical Institute, Slovak Academy of Sciences
May 17—21, 2010
Outline of course
Ken Phillips

LECTURE 1: BASICS and INTRODUCTORY ATOMIC PHYSICS (Monday, May 17 @ 1400; 1 ½ hours)

Units, definitions (we will use cgs units but will relate them to SI units; irradiance/radiance and flux/specific intensity). Examples of spectra. Atoms and ions. Absorption and emission spectra; Kirchhoff's laws. Wavelength ranges. Electron volt. Ion and spectrum notation.

Bohr atom - basic assumptions, Bohr orbits, dimensions and energies. Orbital angular momentum. Electron spin. Rydberg constant, unit of energy. Hydrogen atom, hydrogen isoelectronic sequence. Energy level diagrams.

LECTURE 2: FURTHER ATOMIC PHYSICS, He AND MORE COMPLEX ATOMS (Tuesday, May 18 @ 0930; 1 ½ hours)

Fine structure. Wave mechanics. De Broglie wavelength of electron, Heisenberg uncertainty principle. Wave functions. Schrödinger equation. Electron spin.

Helium atom and more complex atoms. Pauli Principle. Notation (n, l, m_s, m_l; 1,2,3... s,p,d,...)

Periodic table of elements.

LECTURE 3: ATOMIC STATES; SOME SPECTRAL LINES (Tuesday, May 18 @ 1400; 1 ½ hours)

LS coupling, combination of angular and spin momenta.

Electron transitions; selection rules.

Common lines in solar spectra, photosphere, chromosphere, and corona

Notation used to describe atomic states and transitions.

Coronal forbidden lines including the “green line”.

What we see with *TRACE* and *SOHO*/EIT: which spectral lines are included in various filters.

Continua: free-free, free-bound.

LECTURE 4: SOLAR SPECTRA: PHOTOSPHERE and CHROMOSPHERE (Wednesday, May 19 @ 0930; 1 ½ hours)

Total solar radiation, black-body distribution, and effective temperature.

Absorption (Fraunhofer) line spectra: optical depth, strengths of lines. Equivalent widths. Curve of growth.

Limb darkening.

Thermal equilibrium, LTE, NLTE, coronal equilibrium.

Spectral line formation in LTE. Chromospheric absorption lines and non-LTE.

Eddington-Barbier relation.

How the solar chromosphere is observed in the Ca II H and K lines.

Chromospheric network in Ca II and in the ultraviolet.

LECTURE 5: EXCITATION OF CORONAL SPECTRA (Wednesday, May 19 @ 1400; 1 ½ hours)

Ionization equilibrium in the solar and stellar coronae: chief processes.

Coronal emission line spectra in the EUV, UV and SXR. Collision excitation of coronal ions by electrons; contribution or G(T) function. Ion fractions.

Emission measure, differential emission measure.

LECTURE 6: DIAGNOSING PLASMAS FROM THEIR SPECTRA (Thursday, May 20 @ 0930; 1 ½ hours)

Electron temperatures of emitting regions: ratios of spectral lines emitted by highly ionized ions in the corona or coronal active regions. Temperature of flares.

Electron densities: line ratios in the X-ray spectra of solar flares; line ratios in solar UV spectra of active regions and the quiet Sun; using X-ray images of flares.

Line broadening: thermal Doppler broadening - ion temperature. Plasma flows and turbulence.

LECTURE 7: ELEMENT ABUNDANCES (Thursday, May 20 @ 1400; 1 ½ hours)

Element formation: How elements in the Sun and Earth were formed -- fusion reactions in the Big Bang and in stars.

Photospheric abundances are determined from curve-of-growth methods, but more recently model atmospheres are used.

Coronal element abundances are determined from coronal excitation conditions. Recent developments: abundances from the RESIK and RHESSI spacecraft instruments.

Element abundances from solar energetic particles and meteorites.

How the abundance determinations compare: the FIP (first ionization potential) effect. Theories of how the FIP effect arises.

LECTURE 8: SPACECRAFT SPECTROMETERS: SUN-LIKE STARS (Friday, May 21 @ 0930; 1 ½ hours)

UV and X-ray spectrometers – instrumentation and spacecraft. GOES, RHESSI, crystal spectrometers, UV spectrometers on SOHO etc.

Requirements for instruments: wavelength ranges.

Sun-like Stars: visible-light spectroscopy. X-ray and ultraviolet spectroscopy.
Reasons for their Sun-like characteristics.

Stellar flares and prominences.

WRAP-UP SESSION: Questions and discussion. (1100—1115).