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5.15

The Spectral Effects of Dielectronic Recombination in X-ray Photoionized Plasmas

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We present the results of detailed atomic modeling calculations of the Fe L-shell ions under conditions in which the dominant X-ray producing mechanisms are radiative recombination and dielectronic recombination. This scenario is encountered in X-ray photoionized plasmas, such as those which may exist in the circumsource environments of compact X-ray sources. Highly-ionized ions reach their peak abundances at temperatures well below the "ionization temperature", thereby reducing the importance of electron impact in populating excited states.

At these low temperatures, dielectronic recombination can proceed efficiently through radiationless capture of a free electron into a high-n state accompanied by a $\Delta n = 0$ core excitation, the Coster-Kronig mechanism. In ions with partially L shells, the relevant $\Delta n = 0$ transitions are of the type $2s$-$2p$. Radiative stabilization of the "doubly-excited" state completes the recombination, often leaving the recombined ion in an excited state which subsequently decays through a radiative cascade.

The Fe L-shell ions, Fe XVIII-XXIV, are especially vulnerable to this process in X-ray photoionized plasmas, since each has several doubly-excited states with $2s$ vacancies lying just above the ionization limit. At the temperatures expected to exist in the ionization zones of the Fe L-shell ions, the electron energy distribution strongly overlaps these low-lying resonances. The different temperature dependences of competing level populating mechanisms results in several temperature-sensitive line ratios. We discuss the diagnostic potential of line ratios in the X-ray and EUV spectrum of the Fe L-shell ions and their relevance to interpreting spectral data from future astrophysical observatories.

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5.16

Experimental Dielectronic Recombination Results and their Implications for the Solar Transition Region

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Electric and magnetic fields of the magnitudes found in the solar atmosphere can significantly enhance dielectronic recombination (DR) rate coefficients. An experiment to measure DR rates as a function of the external electric field strength will be described. An initial result for the C^{3+} DR rate coefficient through the $2s - 2p$ core transition indicates that the DR rate for a 12 V/cm field is a factor of 7.2 ± 1.8 (1σ) larger than calculated zero field values. This is a field strength comparable to the plasma microfield strength found in the upper transition region where C^{3+} is abundant. We will present calculations showing the implications of field enhanced DR rates on the carbon ionization balance and on observations of solar UV emission lines. In particular, we show that the field enhanced C^{3+} DR rate could lead to as much as a factor of 4 reduction in previously reported C^{3+} fractional abundances. This requires a corresponding increase in emission measures to match the C IV λ1550Å emission line intensities observed in the Sun and late-type stars. This work is supported by NASA under Grant NAGW-1687 to the Harvard College Observatory.

Session 6: Solar Oscillations
Display Session
Regency South

6.01

Doppler Measurement of the Solar Meridional Circulation

D. H. Hathaway (NASA/MSFC)

Doppler velocity images obtained during the summer of 1991 with the GONG breadboard instrument have been analyzed to determine the structure of the solar meridional circulation. Individual Doppler images taken at a 60s cadence have been co-added using a weighting function designed to remove the p-mode oscillation signal. These filtered Doppler images were masked to exclude regions where the solar magnetic field might influence the Doppler measurements. These masked images have been analyzed to determine the rotation profile, the convective limb shift, and the meridional circulation using a recently developed analysis technique which cleanly separates these velocity signals.

The meridional circulation is found to be directed from the equator toward the poles in the observed photospheric layers with a peak velocity of about 30 m s^{-1}. There is also some evidence for a two-cell per hemisphere component in which the flow converges and sinks inward in the mid-latitudes.

The primary source of noise in these measurements is the velocity signal due to supergranulation and the presence of active region magnetic fields. Continued measurements of the meridional circulation will reduce the effects of these signals to provide a more accurate measurement of the details of the circulation pattern and its effect on solar magnetic activity.

6.02

Geometrical Correction of Solar Oscillation Ring Diagrams

F. Hill (NSO) & J. Patron (IAC)

Solar oscillation ring diagrams can be used to infer the two horizontal components of a flow below a region of the photosphere. The selected region can be placed anywhere on the disk, thereby allowing the construction of a map of the subsurface flows as a function of heliographic position and depth. So far, this has been done only for a narrow region close to the solar equator, where the rings are seen to be complete. Away from disk center, the geometrical foreshortening of the spherical solar surface results in a spatially varying non-isotropic apparent Nyquist spatial wavenumber, and hence incomplete rings. The geometric distortion of the rings is further complicated when the region of interest is tracked over several days, adding a time-varying component to the distortion.

We have been developing methods for correcting ring diagrams for the effects of foreshortening. In principle, the geometric effects can be described analytically, but we have chosen to model the process. To do this, simulated high spatial frequency wave fields are projected onto different locations on a sphere and then analyzed to produce artificial ring diagrams. The patterns of ring loss can then be determined, and a correction derived by comparing the "perfect" and incomplete rings. The patterns depend on spatial resolution, disk position, temporal sampling and extent, and tracking strategy. Some examples of these artificial rings will be displayed. In the future, these methods will be used to correct ring diagrams obtained from several different data sets that will eventually yield convection zone flow maps.

6.03

Properties of 5 Minute Period Oscillations in Sunspot Umbrae

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Imaging spectroscopy data of the main umbrae of NOAA #6619 and #6625 were collected from 11 to 16 May 1991 with the MCCD instrument at Mees Solar Observatory, Haleakala, Maui. Each spot was observed for 3 days with 40% temporal coverage at a repetition cycle of 92 seconds; the Nyquist limit of the observations is ν_{Ny} = 5.4 mHz with a frequency resolution of $\nu_R \approx 5.4\times10^{-3}$ mHz. Each scan covers a 38x38 arcsecond region centered on the umbrae with 0.6 arcsecond sized pixels; the spatial Nyquist frequency is $k_{Ny} \approx 5.7$ Mm $^{-1}$ with a resolution of $k_R \approx 0.18$ Mm $^{-1}$.

The data contain many molecular absorption lines near λ = 6404Å which are formed only in the sunspot umbra and not in the surrounding quiet sun. By measuring the Doppler shift of these lines we measure only the velocity of the umbrae; because they are weak we co-add the velocity from 16 lines to reduce the noise. We interpolate the data to an even

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