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NEW POSSIBILITIES FOR THE DIAGNOSTICS OF SOLAR MAGNETIC FIELDS

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The polarized spectrum that is produced by coherent scattering processes has a structural richness comparable to that of the intensity spectrum but different in appearance and physical origin. The amplitudes of the polarization features are influenced by magnetic fields via the Hanle effect in a way that is very different different from the ordinary Zeeman effect. While the main contribution to Zeeman-effect observations comes from the strong fields of the photospheric magnetic flux tubes, the Hanle effect is sensitive to weak magnetic fields, turbulent fields of mixed polarities, and chromospheric fields. As different spectral lines respond very differently to the Hanle effect, the scattering polarization offers novel and rich diagnostic opportunities. In the present overview we illustrate some of these new effects and indicate what can be learnt from them.

KEY WORDS Sun – magnetic fields – polarimetry – Hanle effect

1 WHY ARE NEW DIAGNOSTIC METHODS NEEDED?

Since it was first introduced in astrophysics by Hale (1908), the Zeeman effect has allowed us to map the Sun's magnetic field in great detail. Polarimetric observations in combinations of Zeeman-sensitive lines have revealed that solar magnetic fields have a highly intermittent structure at scales beyond the spatial resolution limit of the observations. Taking advantage of differential effects in the non-linear polarimetric response of the Zeeman effect in different spectral lines it has been possible to extract information about field strengths and thermodynamics at scales beyond the telescope resolution (Stenflo, 1973, 1994). As these are the scales at which most of the magnetic flux resides, one needs to interpret the polarimetric Zeeman-effect data in terms of models for the magnetic field. A consistent picture has emerged in terms of strong-field magnetic flux tubes, which cover on average only about one percent of the solar surface. Inversion of Stokes spectra has led to the construction of flux tube models at increasing levels of sophistication (Solanki, 1993; Nagendra and Stenflo, 1999).

This flux tube picture is however incomplete and unsatisfactory, since it leaves us with a detailed description of 1% of the photosphere while providing few clues