Narrow band filter for solar spectropolarimetry based on Volume Holographic Gratings – A simulation study

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Abstract:

It is essential to observe solar magnetic behavior to understand the dynamics of solar activity. Registering the evolution of the magnetic configuration in intense solar phenomena is crucial to develop more accurate models capable of predicting events with a significant impact on human activity, such as flares and coronal mass ejections. The usual approach to observe the Sun's magnetic field is by indirect estimation, by the solar photons, of the Zeeman effect, which changes the polarization of some spectral lines according to the orientation and strength of the field. The instruments used for this task are called spectropolarimeters. It is currently impossible to simultaneously acquire all the necessary variables (wavelength, polarization, spatial and temporal distribution) with uniform accuracy, making the design of spectropolarimeters a trade-off between components that prioritize one or a set of specific variables. In particular, spectral filters based on volumetric holographic diffraction gratings (VHG), recorded in a lithium niobate crystal, have attractive characteristics to compose the spectral sample selection unit. In the literature, there has been a demonstration of VHG operating at resolutions comparable, and sometimes better, to more traditional solutions used in solar spectropolarimeters. Furthermore, VHG allows the recording of multiple diffraction gratings in the same crystal, allowing simultaneous acquisition of images from different spectral regions, reducing the acquisition time between images. In this work, we present the development and analysis of virtual models of optical systems, for aid in the design of experiments in the laboratory to verify the response of the VHG, operating in a spectral channel, when stimulated by radiation of different wavelengths, polarization state, and propagation direction. Through model simulations, parameters of both the recorded gratings (period and inclination) and the crystal positioning about the incident beam are proposed to achieve the highest diffraction efficiency and spectral resolution. Thus, it was possible to demonstrate that the VHG filter has a spectral resolution similar to standard technologies, such as Fabry Perot, with greater simplicity of operation and manufacture. Moreover, it was also demonstrated that the VHG could act as a tunnelable filter by changing its inclination about the incident beam. The specification of simulated experiments will guide the development of laboratory test benches to validate the results. The effort of this work is focused on understanding the main characteristics of volumetric holographic filters that can improve the

performance of solar spectropolarimeters and how these can be optimized. The virtual model created, and the simulations carried out, is the first step in analyzing the applicability of VHG in a spectropolarimeter in a single spectral channel. However, the designed verification experiments can also be used to verify multi-channel VHG and its impact on acquisition time in solar spectropolarimeter applications.

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