Interaction of photospheric convective plasma and magnetic fields in active and quiet-Sun regions

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The surface of the Sun (photosphere) exhibits a plethora of features which are characterized by the interaction of different spatial and temporal scales of convective plasma flows and magnetic fields emerging from the solar interior. From the vastly visible sunspots, to the very tiny magnetic bright points (MBPs), the evolution of magnetic fields embedded in the photospheric plasma determines some processes occurring at upper solar atmospheric layers related to energy release, solar activity and ultimately having implications on space weather.

By tracking the proper motion of structures in the photosphere over time series of filtergrams (continuum images) acquired by ground-based, balloon-borne and space solar telescopes, we have been able to investigate the plasma dynamics. Furthermore, solar magnetograms are employed to identify the evolution of magnetic structures at different spatial scales. The analyses show the mutual action of plasma flows and magnetic fluxes shaping the configuration of sunspots and small-scale magnetic features in the solar photosphere.

In the first part we will shed light on the interaction between the convective flows in large-scale cells as well as the large-scale magnetic fields in active regions, and investigate the statistical distribution of flow velocities during the evolution and formation a solar active region. We find that the flow fields in an active region can be modelled by a two-component distribution, one for the background flows, and a second one, attributed to the effect of magnetic flux emergence. The plasma flows are found to be mostly correlated to the dynamics of magnetic elements except during rapid magnetic flux emergence where magnetic elements move faster than the corresponding plasma.

Finally, we focus on quiet-Sun regions, to study the influence of plasma motions over small-scale magnetic features. Physical processes at such scales are determinant as building blocks for many others occurring from the lower to the upper layers of the solar atmosphere and beyond, ultimately for understanding the bigger picture of solar activity. In particular, we will discuss on vortex-like plasma motions affecting the dynamics of magnetic concentrations, and on magnetic field emergences covering significant areas of exploding granules and dominated by their convective motions,

In summary, high-cadence magnetograms and horizontal velocity maps are commonly used to study many different small-scale processes such as the formation and disappearance of magnetic bright points accompanying the evolution of a region of interest, but also to probe signatures of magnetic field emergence at multiple scales including the emergence of twisted flux tubes with the characteristic photopheric flow profiles. These investigations are crucial to complement further multi-wavelength multi-layer studies aiming to look into the solar behavior from the lower to the upper solar atmosphere.

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