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Doppler shifts of spectral lines formed in the solar transition region and corona

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Emission lines formed in the transition region and corona show dominantly redshifts and blueshifts, respectively. We investigate the Doppler shifts in a 3D radiation magnetohydrodynamic (MHD) model of the quiet Sun and compare these to observed properties. We concentrate on Si IV 1394 Å originating in the transition region and examine the Doppler shifts of several other spectral lines at different formation temperatures. We construct a radiation MHD model extending from the upper convection zone to the lower corona using the MURaM code. In this quiet Sun model the magnetic field is self-consistently maintained by the action of a small-scale dynamo alone. We synthesize the profiles of several optically thin emission lines, formed at temperatures from the transition region into the corona. We investigate the spatial structure and coverage of red- and blueshifts and how this changes with line-formation temperature. The model successfully reproduces the observed change of average net Doppler shifts from red- to blueshifted from the transition region into the corona. In particular, the model shows a clear imbalance of area coverage of red- vs. blueshifts in the transition region of ca. 80% to 20%, even though it is even a bit larger on the real Sun. We isolate that (at least) four processes generate the systematic Doppler shifts in our model, including pressure enhancement in the transition region, transition region brightenings unrelated to coronal emission, boundaries between cold and hot plasma, and siphon-type flows. We show that there is not the single process that is responsible for the observed net Doppler shifts in the transition region and corona. Because current 3D MHD models do not yet fully capture the evolution of spicules, one of the key ingredients of the chromosphere, most probably these have still to be added to the list of processes responsible for the persistent Doppler shifts.