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Radio seismology of the outer solar corona

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Observed oscillations of coronal loops in extreme ultraviolet (EUV) lines have been successfully used to estimate plasma parameters in the inner corona ($< 0.2\,R_0$, where R_0 is the solar radius). However, coronal seismology in EUV lines fails for higher altitudes because of rapid decrease in line intensity. We aim to use radio observations to estimate the plasma parameters of the outer solar corona ($> 0.2\,R_0$). We used the large Ukrainian radio telescope URAN-2 to observe type IV radio bursts at the frequency range of 8-32 MHz during the time interval of 09:50-12:30 UT on April 14, 2011. The burst was connected to C2.3 flare, which occurred in AR 11190 during 09:38-09:49 UT. The dynamic spectrum of radio emission shows clear quasi-periodic variations in the emission intensity at almost all frequencies. Wavelet analysis at four different frequencies (29 MHz, 25 MHz, 22 MHz, and 14 MHz) shows the quasi-periodic variation of emission intensity with periods of $\sim$ 34 min and $\sim$ 23 min. The periodic variations can be explained by the first and second harmonics of vertical kink oscillation of transequatorial coronal loops, which were excited by the same flare. The apex of transequatorial loops may reach up to 1.2 R_0 altitude. We derive and solve the dispersion relation of trapped magnetohydrodynamic (MHD) oscillations in a longitudinally inhomogeneous magnetic slab. The analysis shows that a thin (with width to length ratio of 0.1), dense (with the ratio of internal and external densities of $\geq$ 20) magnetic slab with weak longitudinal inhomogeneity may trap the observed oscillations. Seismologically estimated Alfvén speed inside the loop at the height of $\sim$ 1 R_0 is $\sim$ 1000 km s^{-1}. The magnetic field strength at this height is estimated as $\sim$ 0.9 G. Extrapolation of magnetic field strength to the inner corona gives $\sim$ 10 G at the height of 0.1 R_0. Radio observations can be successfully used for the sounding of the outer solar corona, where EUV observations of coronal loops fail. Therefore, radio seismology of the outer solar corona is complementary to EUV seismology of the inner corona.

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