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Two-fluid numerical model towards reproducing the observed solar wave cutoffs.

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With use of JOANNA code we developed a numerical model that describes a partially ionized plasma described by a set of two-fluid equations for ion + electron and neutral fluids, coupled by ion-neutral collisions. We used this model to simulate a quiet region of the solar atmosphere with granules spontaneously generated in the photosphere by the underlying solar convective motions. We found that such ongoing granulation excites a wide range of waves propagating into the upper atmospheric layers, with their cutoff frequencies strongly depending on height above the photosphere. We report for the first time numerically obtained cutoff frequencies that are consistent with the cutoff frequencies computed by Stark & Musielak (1993), Kraśkiewicz et al. (2019) and Wójcik et al. (2019). What is even more important, our results remain in agreement with the observational data of Wiśniewska et al. (2016) and Kayshap et al. (2018). As the exact analytical formula for two-fluid cutoff frequencies has not been found up to date, the numerical simulations are crucial tool to answer the ongoing question about impact of different physical processes on cutoffs and their variation in the solar atmosphere.