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Foreshocks ahead of interplanetary shocks observed by STEREO.

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Interplanetary (IP) shocks can be driven in the solar wind by coronal mass ejections and stream interactions. Shocks can perturb large extensions of the heliosphere. In this work we study shocks observed by STEREO during the years 2007-2014. During this period IP shocks had Mach numbers M_{Ms} ∼1.1-4, and the majority were quasi-perpendicular ($\theta_{Bn} > 45^{\circ}$) at the time of spacecraft crossing. We analyze wave properties in the foreshock regions that preced the shocks. We find that when the shock is very oblique with angle $\theta_{Bn} > 60^{\circ}$ a short region of the upstream side is permeated by whistler waves with frequency f∼ 1 Hz. For some less oblique shocks ($60^{\circ} > \theta_{Bn} > 45^{\circ}$), whistlers appear close to the shocks, and wave spectra show two extra peaks, with frequencies f∼10^{-1}, 10^{-2} Hz. The origin of these two wave components may be explained in terms of whistlers propagating from adjacent regions of the shock, or by local instabilities. When the shock is quasi-parallel ($\theta_{Bn} < 45^{\circ}$), the upstream wave spectra tend to be broader, and waves may be generated locally from ion instabilities. In most cases waves are non compressive and in contrast to planetary bow shocks, there are only few examples of nonlinear structures such as shocklets. Our results provide insight about how collisionless shocks in space plasmas form and evolve in different environments.