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# Proton cyclotron waves at Mars: Constraints on mass loading rate and exospheric structure

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Mars is an unmagnetized planet whose ionosphere stands off the solar wind forming an ionopause, magnetosheath and bow shock. The radius of Mars is only 3397 km and the escape velocity almost 5 km/s. Thus the Martian exosphere should extend into the solar wind and would be expected to create proton cyclotron waves when the exospheric hydrogen is ionized. Mars Global Surveyor data reveal that the occurrence of proton cyclotron waves in the solar wind near Mars to be very extensive. About 30% of the time, proton cyclotron waves are found extending from the magnetosheath of Mars up to 15 RM with amplitudes that vary only slowly with distance. Since the electromagnetic energy flux of proton cyclotron waves is proportional to the rate of loss of the hydrogen exosphere from the planet, this simple observation indicates that Mars is losing about 1024 protons per second due to solar wind pickup. When only the wave cases in strong background magnetic fields are examined in a magnetic-electric coordinate system, a strong asymmetry is seen in the direction of the interplanetary electric field. This asymmetry indicates that the production of the extended hot hydrogen exosphere involves an electric field acceleration step followed by neutralization allowing the pickup process to extend far on only one side of the planet.