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Energetic particles and radar blackouts at Mars

Mark Lester[1], Beatriz Sanchez-Cano[1], Daniel Potts, Rob Lillis[2], Marco Cartacci[3], Fabrizio Bernardini[3], Roberto Orosei[4], Matthew Perry[5], Nathaniel Putzig[5], Bruce Campbell[6], Pierre-Louis Blelly[7], Steve Milan[1], Hermann Opgenoorth[8,1], and Olivier Witasse[9]

[1]University of Leicester, Dept. of Physics and Astronomy, Leicester LE1 7RH, United Kingdom of Great Britain – England, Scotland, Wales (mle@le.ac.uk)

[2]Space Sciences Laboratory, University of California, Berkeley, CA, USA

[3]Istituto di Astrofisica e Planetologia Spaziali, Istituto Nazionale di Astrofisica, Rome, Italy

[4]Istituto di Radioastronomia, Istituto Nazionale di Astrofisica, Bologna, Italy

[5]Planetary Science Institute, Lakewood, CO, USA

[6]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, DC, USA

[7]Institut de Recherche en Astrophysique et Planétologie, Toulouse, France

[8]Umeå University, Umea, Sweden

[9]European Space Agency (ESA), European Space Research and Technology Centre (ESTEC), Keplerlaan 1, 2201 AZ Noordwijk, The Netherlands

We present the first long-term characterization of the lower ionosphere of Mars, a region previously inaccessible to orbital observations, based on an analysis of radar echo blackouts observed by MARSIS on Mars Express and SHARAD on the Mars Reconnaissance Orbiter from 2006 to 2017. A blackout occurs when the expected surface reflection is partly to fully attenuated for portions of an observation. Enhanced ionization at altitudes of 60 to 90 km, below the main ionospheric electron density peak, results in the absorption of the radar signal, leading to a radar blackout. MARSIS, operating at frequencies between 1.8 and 5 MHz suffered more blackouts than SHARAD, which has a higher carrier frequency (20 MHz). More events are seen during solar maximum while there is no apparent relationship between blackout occurrence and crustal magnetic fields. Blackouts do occur during both nightside and dayside observations, and have an interesting variation with solar zenith angle. Analysis of MAVEN Solar Energetic Particle (SEP) electron counts between 20 and 200 keV during selected events demonstrates that these electrons are responsible for such events, and we investigate the minimum SEP electron fluxes required to ionize the lower atmosphere and produce measurable attenuation. When both radars observe a radar blackout at the same time, the SEP electron fluxes are at their highest. For certain events, we find that the average spectrum responsible for a blackout is particularly enhanced at the higher energy end of the spectrum, i.e. above 70 keV . This study is, therefore, important for future communications for human exploration of Mars.