Atmospheric escape from M-dwarf exoplanets and implications for habitability

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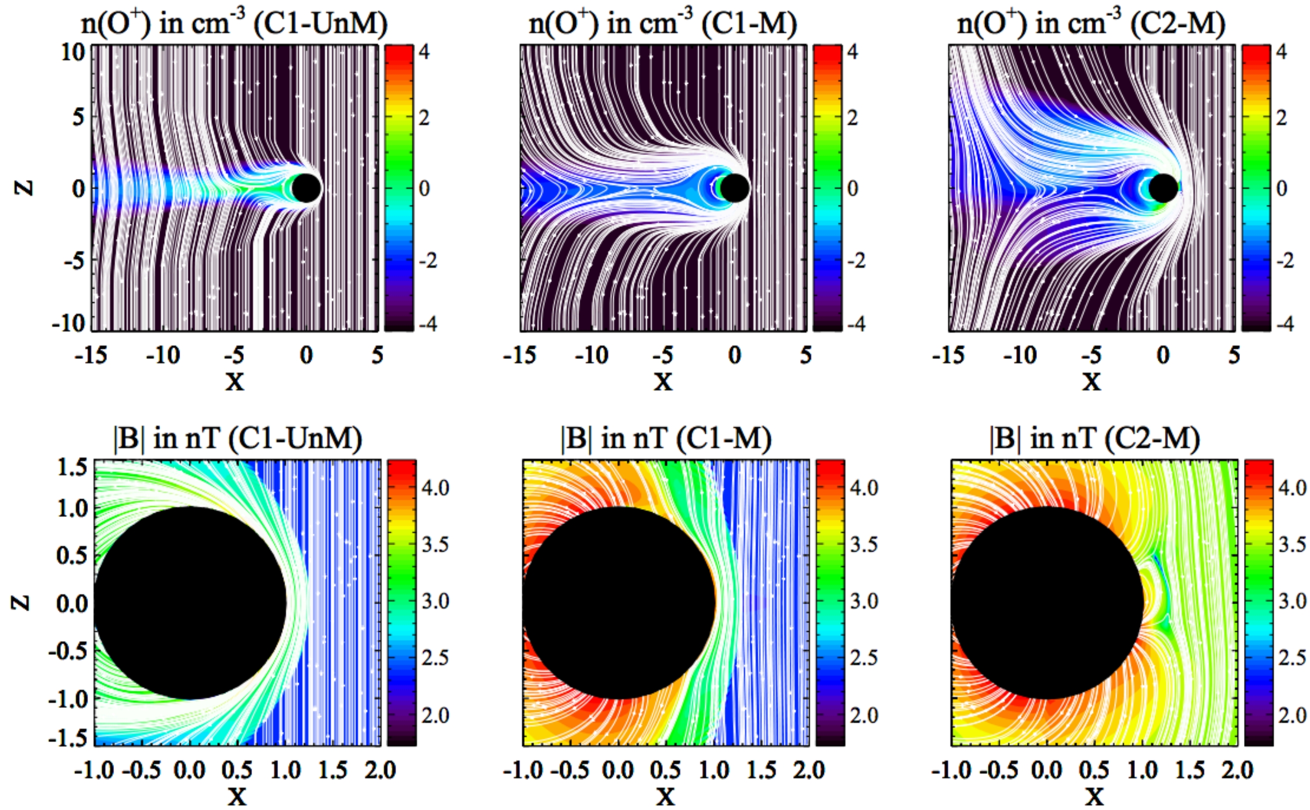
In the last two decades, the field of exoplanets has witnessed a tremendous creative surge. Research in exoplanets now encompasses a wide range of fields ranging from astrophysics to heliophysics and climate science. One of the primary objectives of studying exoplanets is to determine the criteria for habitability, and whether certain exoplanets meet these requirements. The classical definition of the Habitable Zone (HZ) is the region around a star where liquid water can exist on the planetary surface given sufficient atmospheric pressure. However, this definition largely ignores the impact of the stellar wind and stellar magnetic activity on the erosion of an exoplanet's atmosphere. Amongst the many factors that determine habitability, understanding the mechanisms of atmospheric loss is of paramount importance.

We will discuss the impact of exoplanetary space weather on the long-term climate evolution and habitability, which offers fresh insights concerning the habitability of exoplanets, especially those orbiting M-dwarfs, such as Proxima b and the TRAPPIST-1 planets. I will focus on a wide range of atmospheric compositions, ranging from exo-Venus candidates to ocean worlds; the latter being a unique class of planets with water-rich surfaces and atmospheres that do not currently exist in our Solar system. For each of these cases, we will demonstrate the importance of the exoplanetary space weather on atmospheric ion loss and habitability.

Keywords: atmospheric escape, planetary habitability, M-dwarf exoplanets, stellar wind and magnetic activity, Proxima b, the TRAPPIST-1 planets


n(O+) in cm-3 (C1-UnM)
n(O+) in cm-3 (C1-M)
n(O+) in cm-3 (C2-M)
|B| in nT (C1-UnM)
|B| in nT (C1-M)
|B| in nT (C2-M)
Z
X
10
5
0
-5
-10
-15
4
2
-2
-4
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
2.0
2.5
3.0
3.5
4.0