Exploring Habitability and Radio Emission in Proxima b's Space Weather Environment

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M-dwarfs and radio emission

Stellar activity

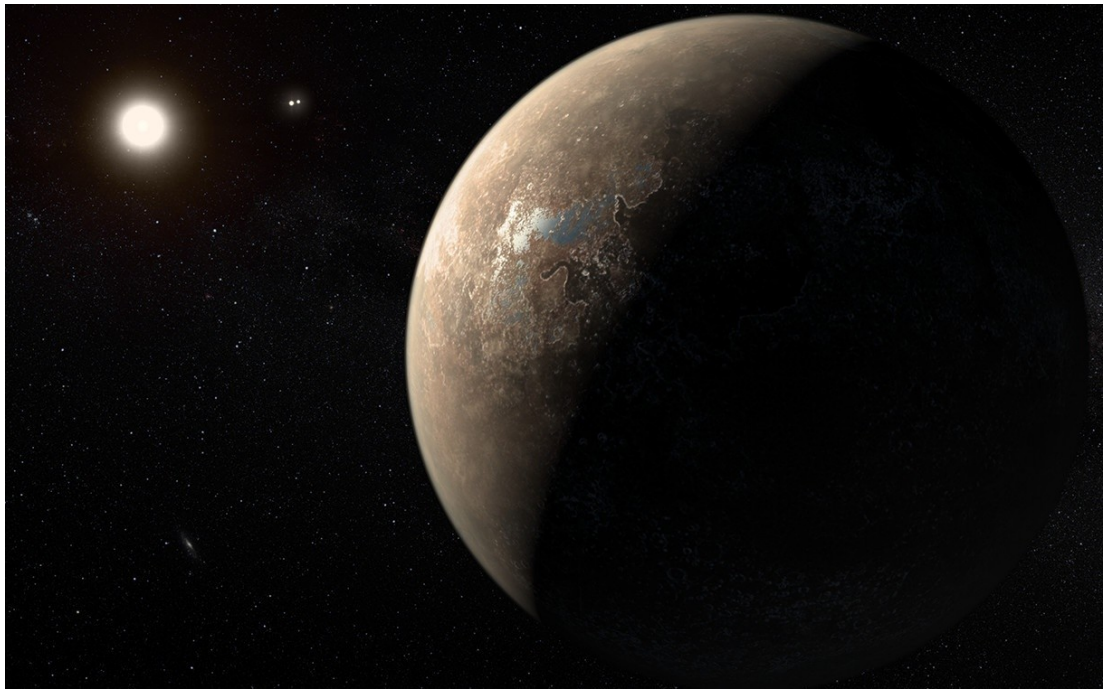
Coronal mass ejections, flares
Magnetic field
Impact on planet habitability

Planetary magnetic field

Shield
Habitability indicator
Informs on planet interior

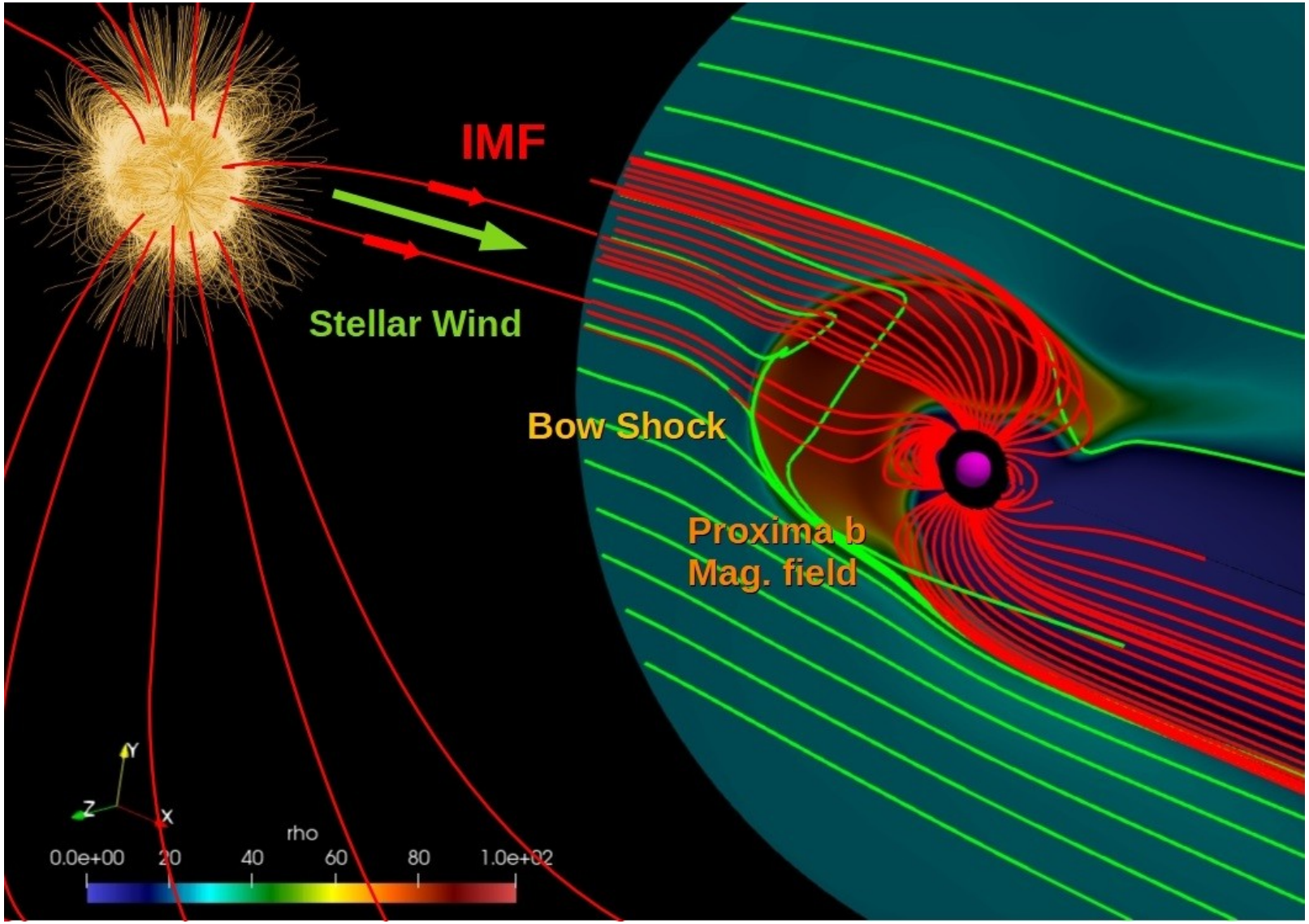
PLUTO simulations of the space weather in Proxima b

- Safe for life?
- Direct emission from the magnetosphere?



Peña-Moñino et al (2024), A&A 688, A138.
DOI: 10.1051/0004-6361/202349042

PLUTO simulations of the space weather in Proxima b



PLUTO simulations of the space weather in Proxima b

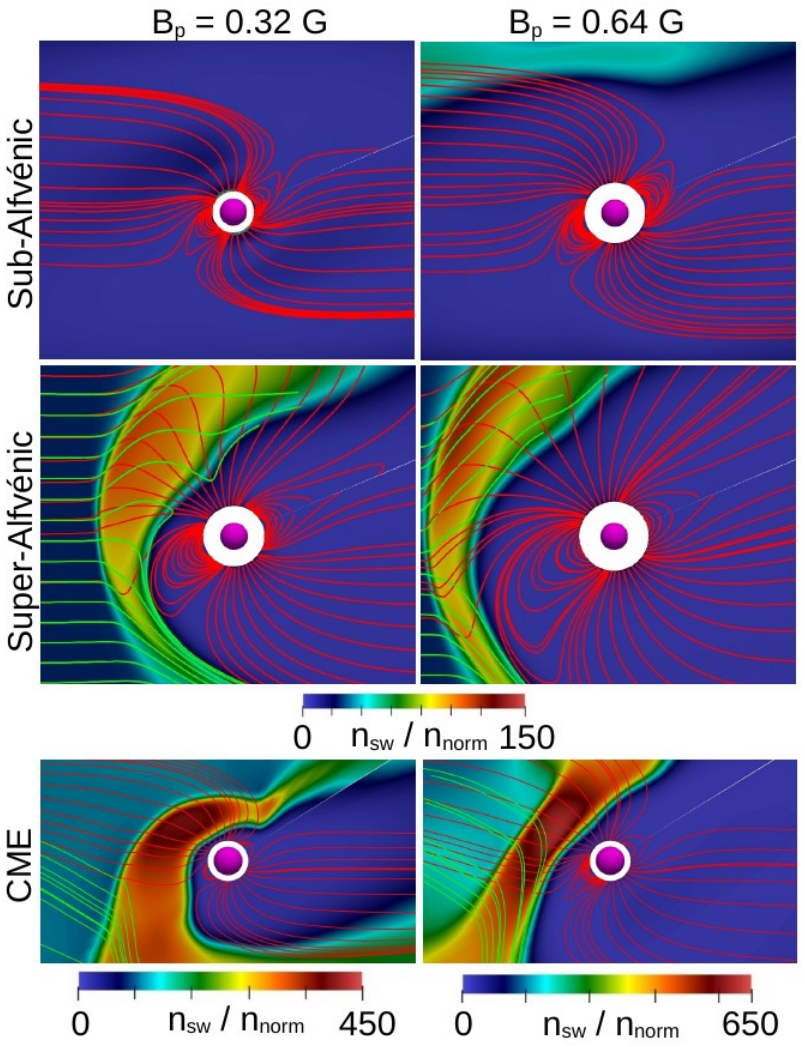
WIND PARAMETERS

Parameter	Calm space weather		Extreme space weather
	Sub-Alfvénic scenario	Super-Alfvénic scenario	CME scenario
n_{sw} [cm^{-3}]	50	50	250
$\|v_{sw}\|$ [10^7 cm s^{-1}]	5	10	25
B_{IMF} [mG]	3.2	1.6	16
$B_{Proxima}$ [G]	1200	600	600
$B_{Proxima\,b}$ [G]	0.16–1.28	0.16–1.28	0.16–0.64
i	[0° - 90°]	[0° - 90°]	[0° - 45°]

PLUTO simulations of the space weather in Proxima b

PLANET PARAMETERS

- Inclination: 0 to 90º
- B_{planet}: 0.16 to 1.28 G



Peña-Moñino et al 2024

PLUTO simulations of the space weather in Proxima b

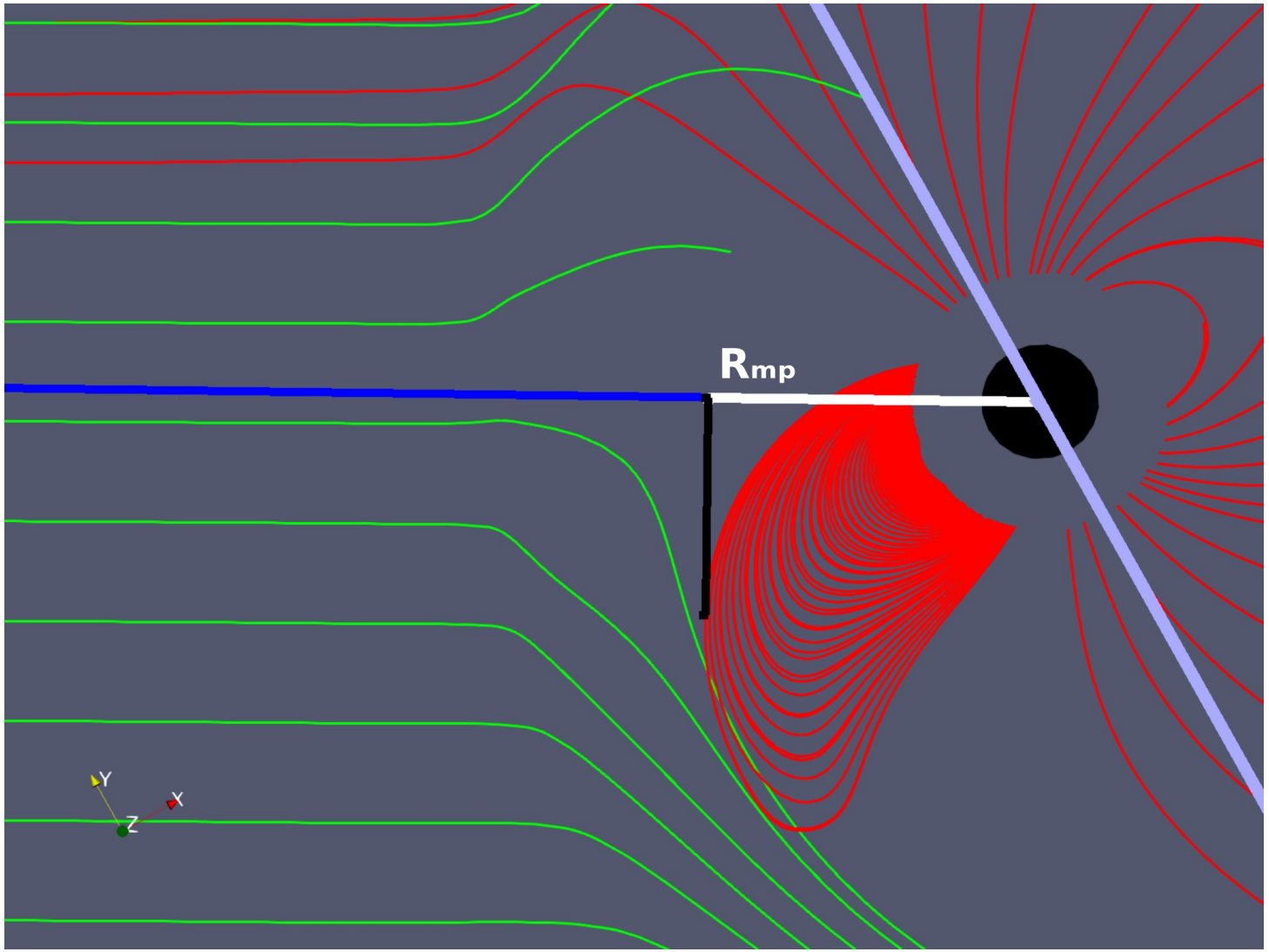
R_{mp} to infer habitability

If $R_{mp} < R_p$: surface sterilized

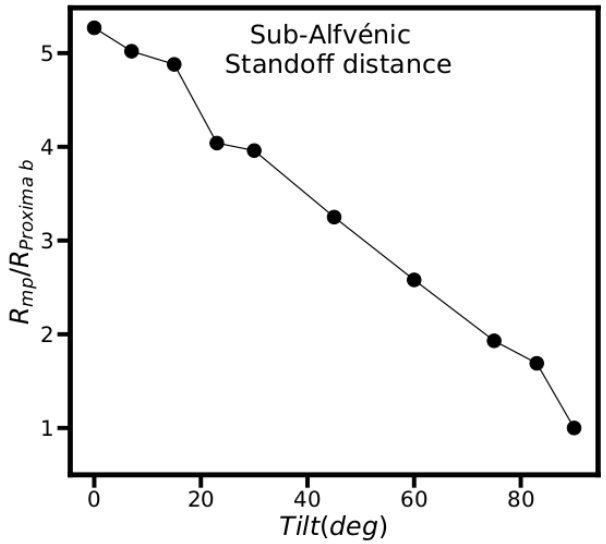
$$\frac{R_{\rm mp}}{R_{\rm p}} = \left[\frac{\alpha \mathcal{M}_{\rm p}{}^2/\pi}{m_{\rm p} n_{\rm sw} v_{\rm sw}^2 + \frac{B_{\rm IMF}^2}{4\pi} + \frac{2 m_p n_{\rm sw} c_{\rm sw}^2}{\gamma} - m_{\rm p} n_{\rm bs} v_{\rm th,msp}^2} \right]^{1/6}$$

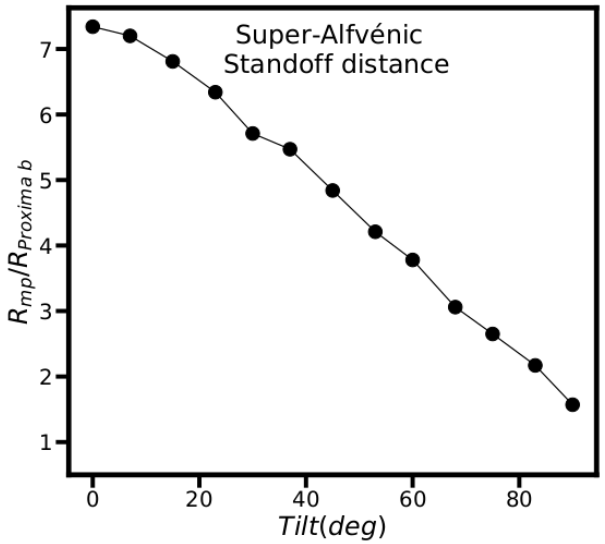
Varella et al. 2022

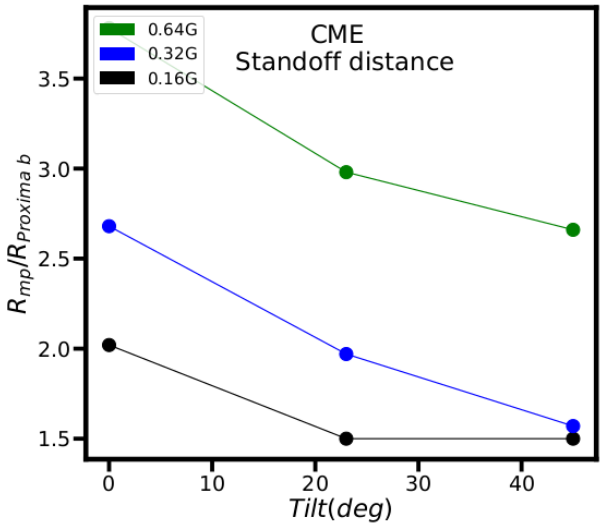
PLUTO simulations of the space weather in Proxima b

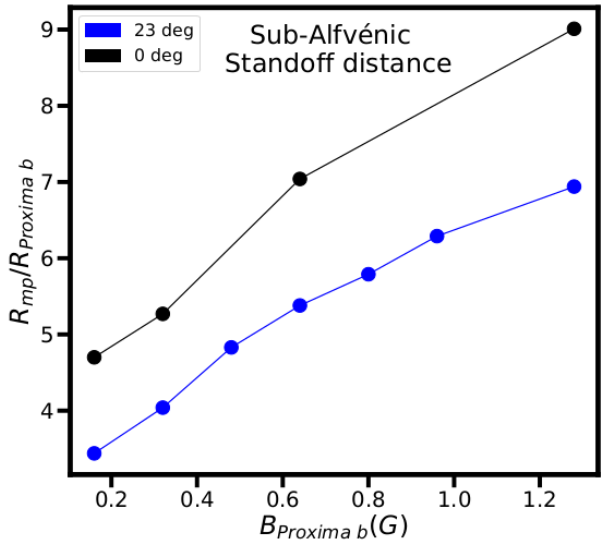


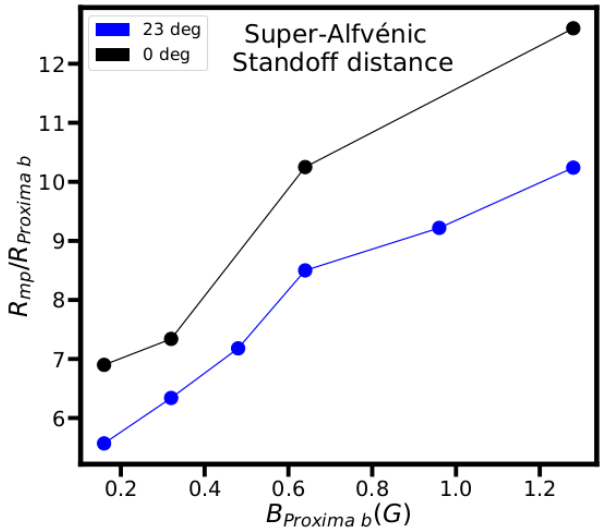
PLUTO simulations of the space weather in Proxima b

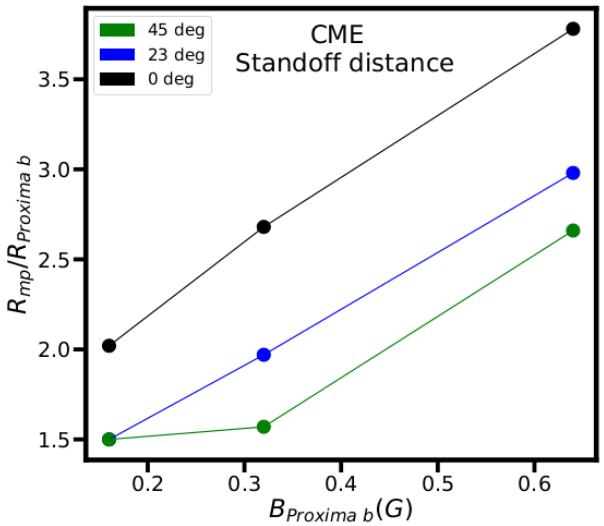






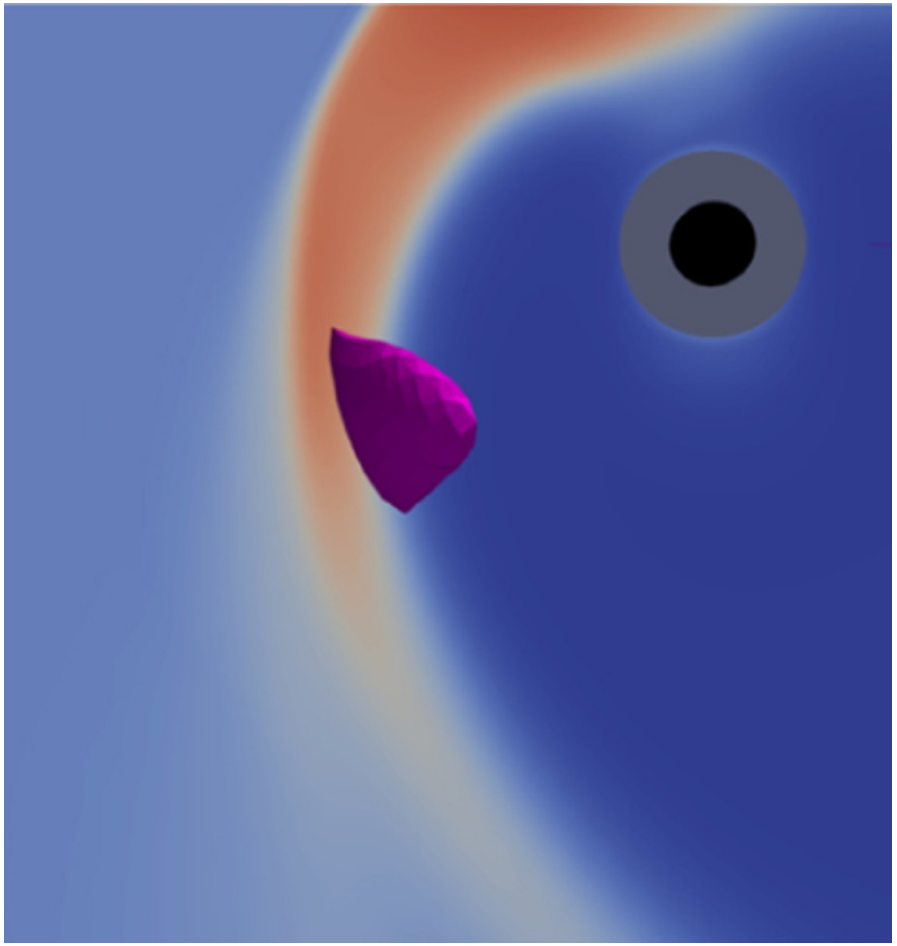






PLUTO simulations of the space weather in Proxima b

RADIO EMISSION



Peña-Moñino et al 2024

PLUTO simulations of the space weather in Proxima b

RADIO EMISSION

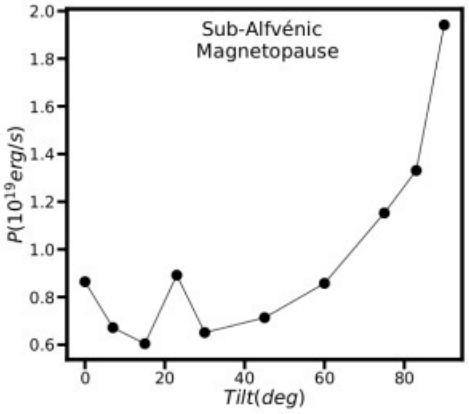
CALM WEATHER

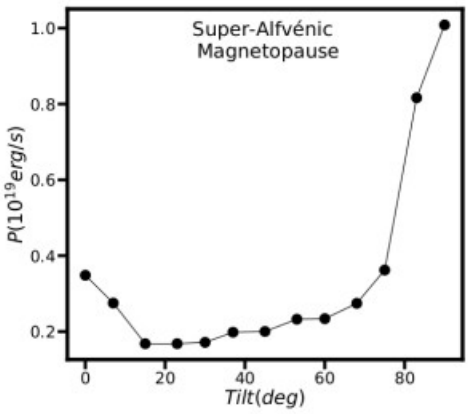
Sub-Alfvénic

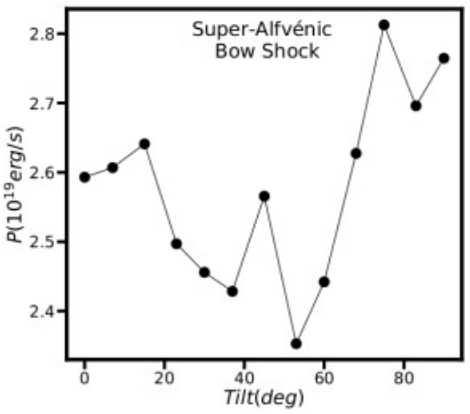
Super-Alfvénic

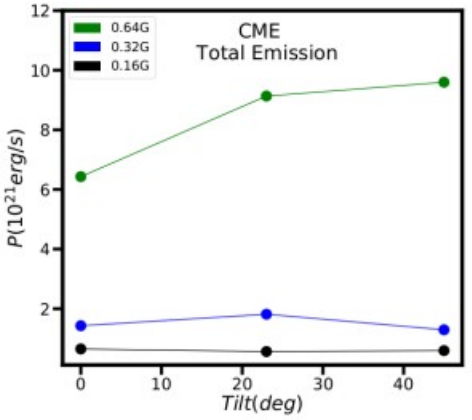
EXTREME

CME









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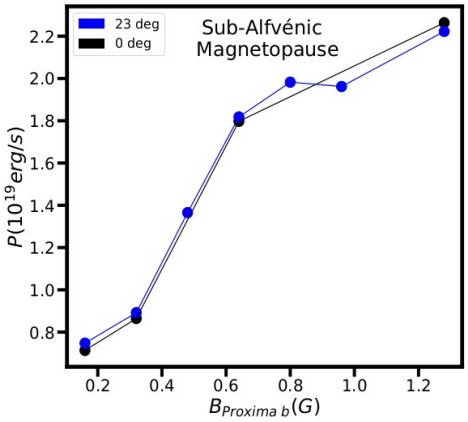
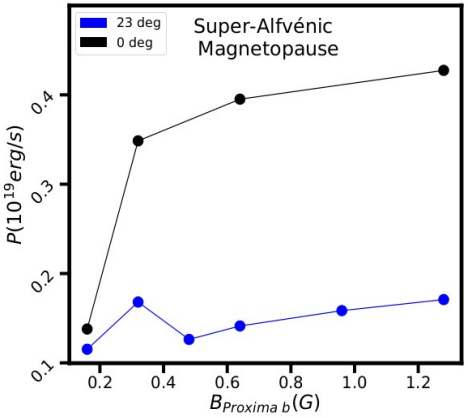
PLUTO simulations of the space weather in Proxima b

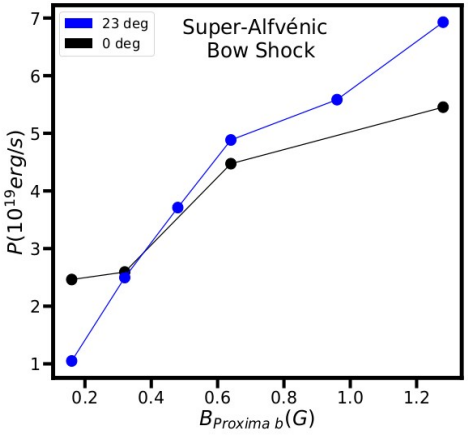
RADIO EMISSION

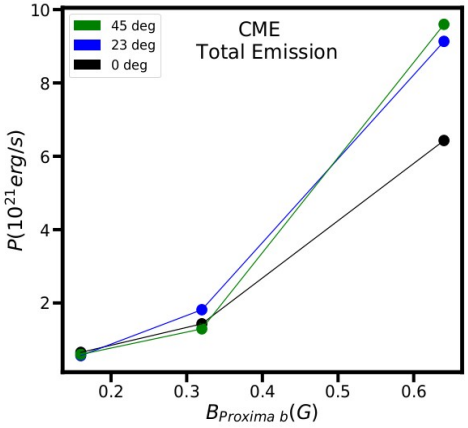
CALM WEATHER **EXTREME**

Sub-Alfvénic Super-Alfvénic CME









Peña-Moñino et al 2024

PLUTO simulations of the space weather in Proxima b

- R_{mp} decreases with tilt and increases with B_p. Larger in the super-Alfvénic regime: Magnetic erosion stronger kinematic comrpession.
- Proxima b shielded for most cases.
- Emission: bow shock-dominated emission. 10^{18} - 10^{22} egs/s

THANK YOU

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