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Interior heating and outgassing of Proxima Cen b: Identification of critical parameters

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Since the discovery of a potentially low-mass exoplanet around our nearest neighbour star Proxima Centauri, several works have investigated the likelihood of a shielding atmosphere and therefore the potential surface habitability of Proxima Cen b. However, outgassing processes are influenced by several different (unknown) factors such as the actual planet mass, mantle and core composition, and different heating mechanisms in the interior.
We aim to identify the critical parameters that influence the mantle and surface evolution of the planet over time, as well as to potentially constrain the time-dependent input of volatiles from mantle into the atmosphere.

To study the coupled star-planet evolution, we analyse the heating produced in the interior of Proxima Cen b due to induction heating, which strongly varies with both depth and latitude. We calculate different rotation evolutionary tracks for Proxima Centauri and investigate the change in its rotation period and magnetic field strength. Unlike the Sun, Proxima Centauri possesses a very strong magnetic field of at least a few hundred Gauss, which was likely higher in the past.
We apply an interior structure model for varying planet masses (derived from the unknown inclination of observation of the Proxima Centauri system) and iron weight fractions, i.e. different core sizes, in the range of observed Fe-Mg variations in the stellar spectrum.
We use a mantle convection model to study the thermal evolution and outgassing efficiency of Proxima Cen b. For unknown planetary parameters such as initial conditions we chose randomly selected values. We take into account heating in the interior due to variable radioactive heat sources and latitute- and radius-dependent induction heating, and compare the heating efficiency to tidal heating.

Our results show that induction heating may have been significant in the past, leading to local temperature increases of several hundreds of Kelvin (see Fig. 1). This early heating leads to an earlier depletion of the interior and volatile outgassing compared to if the planet would not have been subject to induction heating. We show that induction heating has an impact comparable to tidal heating when assuming latest estimates on its eccentricity. We furthermore find that the planet mass (linked to the planetary orbital inclination) has a first-order influence on the efficiency of outgassing from the interior.

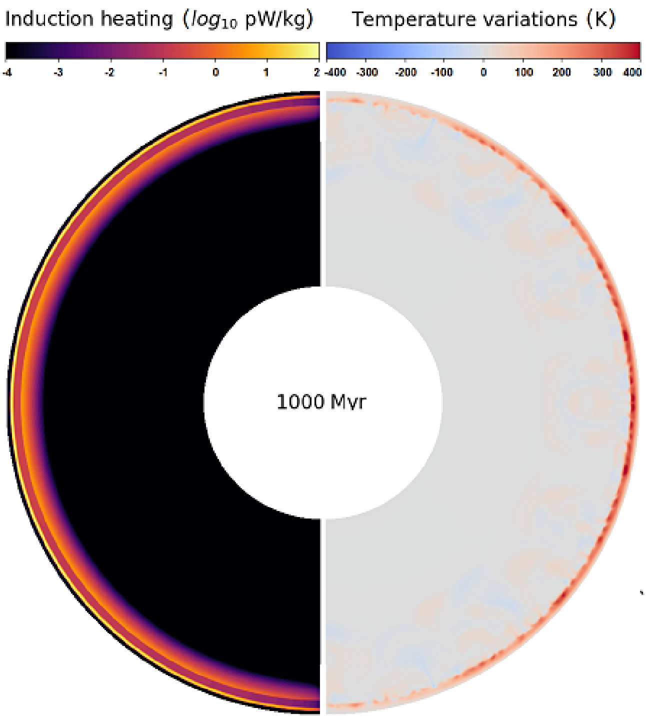

Fig 1: Local induction heating and resulting temperature variations compared to a simulation without induction heating after 1 Gyr of thermal evolution for an example rocky planet of 1.8 Earth masses with an iron content of 20 wt-%.