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Identifying the upper atmosphere structure of the inflated hot sub-Neptune CoRoT-24b

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The CoRoT satellite mission discovered two Neptune-type planets, CoRoT-24b and CoRoT-24c, with observed transit radii of $\approx 3.7 R_{\rm Earth}$ and $\approx 4.9 R_{\rm Earth}$ and masses of $\leq 5.7 M_{\rm Earth}$ and $\approx 28 M_{\rm Earth}$, respectively. From the deduced low mean densities it can be expected that their planetary cores are most likely surrounded by H_2 dominated envelopes. While having very similar radii, the outer planet CoRoT-24c is at least 4.9 times more massive than its neighbour, indicating that their atmospheres can be fundamentally different. Therefore, we have investigated the upper atmosphere structure and escape rates of these two planets. We applied a hydrodynamic upper atmosphere model including heating by absorption of stellar extreme ultraviolet and X-ray (XUV) radiation, under the assumption that the observed transit radius $R_{\rm T}$ is produced by Rayleigh scattering and H_2-H_2 collision absorption in a pure hydrogen atmosphere. This corresponds to a pressure level near 1 bar. We find an unsustainably high hydrodynamic escape rate of 1.6×10^{11} g/s for the atmosphere of CoRoT-24b. If real, such high atmospheric escape would lead to substantial mass loss from the planetary atmosphere, shrinking it to $\approx 2.2 R_{\rm Earth}$ within ≈ 4 Myr, which is inconsistent with the old age of the system. The solution to this discrepancy is that the observed transit radius $R_{\rm T}$ must be 30-60% larger than the actual planetary radius at the 1 bar pressure level. We suggest that the observed transit radius $R_{\rm T}$ is produced by absorption through scattering processes due to high altitude clouds or hazes. The Kepler satellite has discovered similar close-in low-density Neptune-type planets. We propose that it is very likely that the observed transit radii for the vast majority of these planets also differ from their actual planetary radii at the 1 bar pressure level. This would introduce a systematic bias in the measured radii and has dramatic implications in the determination of the mass-radius relation and for planet synthesis studies. Our finding will become even more relevant in the near future with the launch of space missions like CHEOPS, TESS, the JWST and PLATO.