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Title: Physical conditions of the interstellar medium of high-redshift, strongly lensed submillimetre galaxies from the Herschel-ATLAS
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Abstract: We present Herschel-Spectral and Photometric Imaging Receiver (SPIRE) Fourier transform spectrometer (FTS) and radio follow-up observations of two Herschel-Astrophysical Terahertz Large Area Survey (H-ATLAS)-detected strongly lensed distant galaxies. In one of the targeted galaxies H-ATLAS J090311.6+003906 (SDP. 81), we detect [O III] 88 mu m and [C II] 158 mu m lines at a signal-to-noise ratio of similar to 5. We do not have any positive line identification in the other fainter target H-ATLAS J091305.0-005343 (SDP. 130). Currently, SDP. 81 is the faintest submillimetre galaxy with positive line detections with the FTS, with continuum flux just below 200 mJy in the 200-600 mu m wavelength range. The derived redshift of SDP. 81 from the two detections is z = 3.043 +/- 0.012, in agreement with ground-based CO measurements. This is the first detection by Herschel of the [O III] 88 mu m line in a galaxy at redshift higher than 0.05. Comparing the observed lines and line ratios with a grid of photodissociation region (PDR) models with different physical conditions, we derive the PDR cloud density n approximate to 2000 cm(-3) and the far-ultraviolet ionizing radiation field G(0) approximate to 200 (in units of the Habing field - the local Galactic interstellar radiation field of 1.6 x 10(-6) W m(-2)). Using the CO-derived molecular mass and the PDR properties, we estimate the effective radius of the emitting region to be 500-700 pc. These characteristics are typical for star-forming, high-redshift galaxies. The radio observations indicate that SDP. 81 deviates significantly from the local far-infrared/radio (FIR/radio) correlation, which hints that some fraction of the radio emission is coming from an active galactic nucleus (AGN). The constraints on the source size from millimetre-wave observations put a very conservative upper limit of the possible AGN contribution to less than 33 per cent. These indications, together with the high [OIII]/FIR ratio and the upper limit of [O I] 63 mu m/[C II] 158 mu m, suggest that some fraction of the ionizing radiation is likely to originate from the AGN.