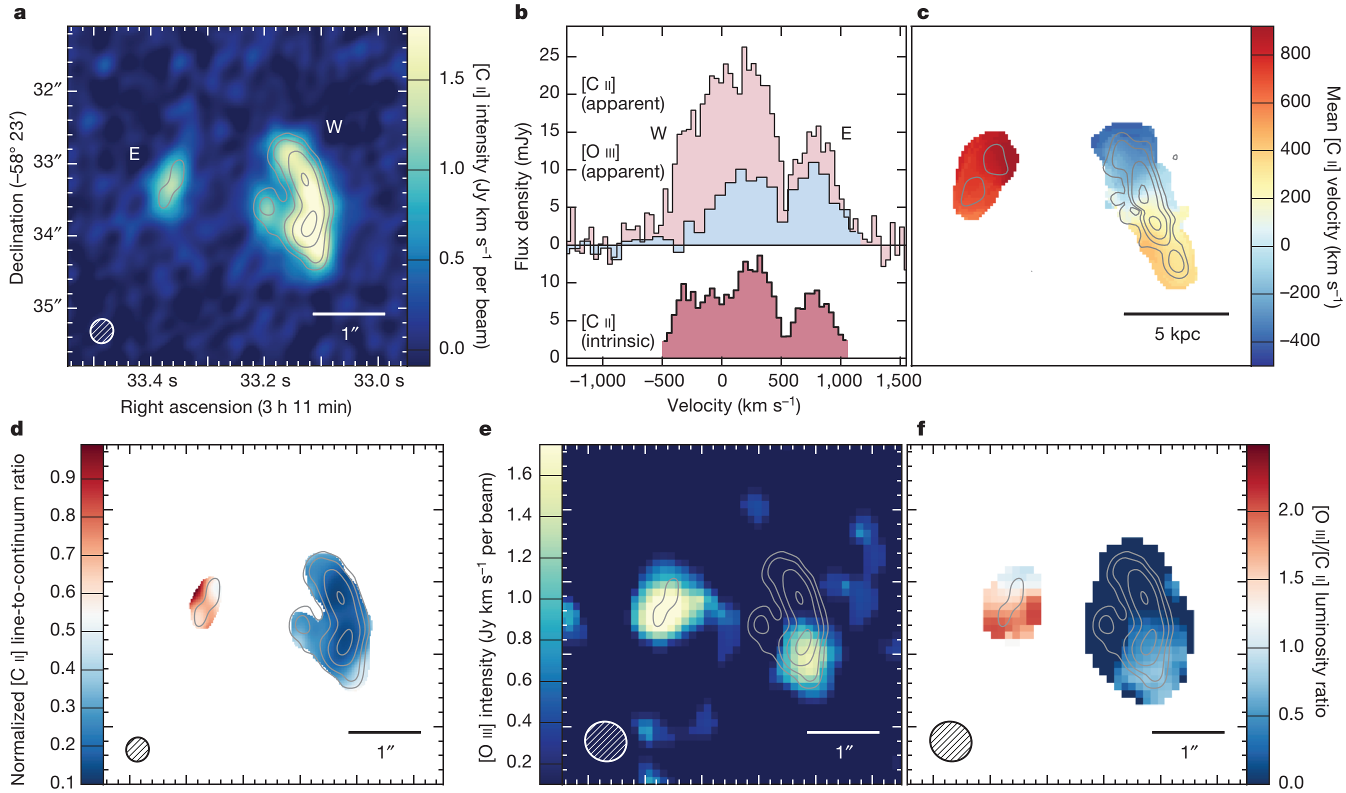

Figure 1 | Continuum, [C II] and [O III] emission from SPT0311−58 and the inferred source-plane structure. a, Emission in the 157.74-μm fine-structure line of ionized carbon ([C II]) as measured at 240.57 GHz with ALMA, integrated over 1,500 km s^{-1} of velocity, is shown with the colour scale. The range in flux per synthesized beam (the 0.25″ × 0.30″ beam is shown in the lower left) is provided at right. The rest-frame 160-μm continuum emission that was measured simultaneously is overlaid, with contours at 8, 16, 32 and 64 times the noise level of 34 μJy per beam. SPT0311−58 E and SPT0311−58 W are labelled. **b**, The continuum-subtracted, source-integrated [C II] (red) and [O III] (blue) spectra. The upper spectra are as observed ('apparent') with no correction for lensing, whereas the lensing-corrected ('intrinsic') [C II] spectrum is shown at the bottom. SPT0311−58 E and SPT0311−58 W separate almost completely at a velocity of 500 km s^{-1}. **c**, The source-plane structure after removing the effect of gravitational lensing. The image is coloured according to the flux-weighted mean velocity, showing that the two objects are physically associated but separated by roughly 700 km s^{-1} in velocity and 8 kpc (projected) in space. The reconstructed 160-μm continuum emission is shown as contours. The scale bar represents the angular size of 5 kpc in the source plane. **d**, The line-to-continuum ratio at the 158-μm wavelength of [C II], normalized to the map peak. The [C II] emission from SPT0311−58 E is much brighter relative to its continuum than for SPT0311−58 W. **e**, Velocity-integrated emission in the 88.36-μm fine-structure line of doubly ionized oxygen ([O III]) as measured at 429.49 GHz with ALMA (colour scale). The data have an intrinsic angular resolution of 0.2″ × 0.3″, but have been tapered to 0.5″ owing to the lower signal-to-noise ratio of these data. **f**, The luminosity ratio between the [O III] and [C II] lines. As for the [C II] line-to-continuum ratio, a large disparity is seen between SPT0311−58 E and SPT0311−58 W. The sky coordinates and contours for rest-frame 160-μm continuum emission in **d**–**f** are the same as in **a**.

source plane. SPT0311−58 E has an effective radius of 1.1 kpc, whereas SPT0311−58 W has a clumpy, elongated structure that is 7.5 kpc across. The (flux-weighted) source-averaged magnifications of each galaxy and of the system as a whole are quite low ($\mu_E = 1.3$, $\mu_W = 2.2$, $\mu_{tot} = 2.0$) because SPT0311−58 W is extended relative to the lensing caustic and SPT0311−58 E is far from the region of high magnification. The same lensing model applied to the channelized [C II] data reveals a clear velocity gradient across SPT0311−58 W, which could be due to either rotational motions or a more complicated source structure coalescing at the end of a merger.

Having characterized the lensing geometry, it is clear that the two galaxies that comprise SPT0311−58 are extremely luminous. Their intrinsic infrared (8–1,000 μm) luminosities have been determined from observations of rest-frame ultraviolet-to-submillimetre emission (see Methods section 'Modelling the SED') to be $L_{IR} = (4.6 \pm 1.2) \times 10^{12} L_\odot$ and $L_{IR} = (33 \pm 7) \times 10^{12} L_\odot$ for SPT0311−58 E and SPT0311−58 W, respectively, where $L_\odot$ is the luminosity of the Sun. Assuming that these sources are powered by star formation, as suggested by their extended far-infrared emission, these luminosities are unprecedented at $z > 6$. The implied (magnification-corrected) star-formation rates are correspondingly enormous—$(540 \pm 175) M_\odot$ yr^{-1} and $(2{,}900 \pm 1{,}800) M_\odot$ yr^{-1}, where $M_\odot$ is the mass of the Sun—probably owing to the increased instability associated with the tidal forces experienced by merging galaxies[13]. The components of SPT0311−58 have luminosities and star-formation rates similar to the other massive, $z > 6$ galaxies identified by their dust emission, including HFLS3 ($z = 6.34$), which has a star-formation rate of $1{,}300 M_\odot$ yr^{-1} after correcting for a magnification factor[14] of 2.2, and a close quasar–galaxy pair[15] at $z = 6.59$, the components of which are forming stars at rates of $1{,}900 M_\odot$ yr^{-1} and $800 M_\odot$ yr^{-1}, respectively. However, unlike the latter case, there is no evidence of a black hole in either source in SPT0311−58.

Unlike any other massive dusty source at $z > 6$, the rest-frame ultraviolet emission of SPT0311−58 E is clearly detectable with modest integration by the Hubble Space Telescope. The detected ultraviolet luminosity ($L_{UV} = (7.4 \pm 0.7) \times 10^{10} L_\odot$) suggests a star-formation rate of only $13 M_\odot$ yr^{-1}, 2% of the rate derived from the far-infrared emission, consistent with SPT0311−58 E forming most of its stars behind an obscuring veil of dust. The inferred stellar mass for this galaxy (see Methods section 'Modelling the SED') is $(3.5 \pm 1.5) \times 10^{10} M_\odot$. Although no stellar light is convincingly seen from SPT0311−58 W, the absence of rest-frame ultraviolet emission is probably explained by heavy dust