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Sub-arcsecond imaging of bright radio galaxies at 150 MHz

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1 Extended Abstract

The steep decline of the stellar mass function at the highest stellar masses of galaxies, and the kinetic power of radio galaxies, is consistent with the picture in which radio galaxies output bulk kinetic energy into their surroundings which is significant for galaxy evolution over cosmic time. The brightest radio galaxies in the radio sky, such as 3C radio galaxies, are the most widely studied in terms of their dynamics and energetics. However, these studies have primarily been performed at GHz frequencies, where high resolution imaging has been possible in the past, although at the expense of losing emission from the oldest radiating particles which are only visible at the lowest radio frequencies. Hence, our understanding of radio galaxy behaviour in general is missing without high resolution and low frequency studies. In this extended abstract, and subsequent talk, I present the first high resolution and low frequency study of the radio galaxy 3C34.

3C34 is a bright (> 12 Jy at 150 MHz) and large (> 1 arcmin) radio galaxy that resides in a compact cluster at a redshift of 0.69. Many high frequency (> 1 GHz) studies at high resolution have been performed on this object, including its double-hotspot structure, polarization and low-surface brightness. However, the lowest surface brightness emission can only be revealed at low frequencies. In my talk I present the first low frequency (150 MHz) high resolution (0.3 arcsec) image of 3C34, using observations from the LOFAR Two-Metre Sky Survey (LoTSS), showing a plethora of new radio emission seen for the first time for this source. In particular, a large filament of faint emission at the base of the lobes is discovered, and strikingly flows outside the lobes and forms diffuse tails – what was previously known as a wing. This has direct implications for our knowledge of radio galaxy lobe evolution. In particular, the formation of wings as bulk backflow of lobe plasma may be challenged by the idea that the wings are simply steep-spectrum filaments observed at low resolution. We also report a tentative detection of an 'edge' filament – a long filament running along the edge of the lobes beginning from the hotspot. Our new images also reveal general complex emission in the lobes that is only seen at low frequencies. Combining our data with 5 GHz archival VLA data, we analyse the spectral indices of the multiple hotspot structures, and discuss the implications for jet energetics and particle acceleration. I also present some of the challenging techniques required to calibrate low frequency data with international baselines, while presenting a brief discussion of polarization at sub-arcsecond resolution with LOFAR.

Studies such as these will be crucial, as the upcoming SKA and SKA pathfinder telescopes will enable such studies of the population, and it is important to understand which studies will be enabled with these telescopes. In particular, high resolution population studies of radio galaxies will give us robust statistics on radio galaxy energetics and feedback processes, as well as on the physics of plasma turbulence and particle acceleration.