Astronomy in Focus, XXIXB, Focus Meeting 5
XXIXth IAU General Assembly, August 2015
Piero Benvenuti, ed.

doi:10.1017/S174392131600449X

Planck on Extragalactic Radio Sources: Data and Findings

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Abstract. *Planck* scanned the entire sky every six months at nine frequencies bands from 28 to 857 GHz with enough sensitivity to detect over a thousand radio sources. It thus provided measurements of the mm and sub-mm spectra of these sources in a regular cadence, even at wavelengths hard to observe from the ground. Polarization measurements (or upper limits) are provided for brighter sources at 28-353 GHz. Finally, *Planck* is calibrated to $< 1\%$ accuracy in most of its frequency bands. I briefly introduce the valuable data set *Planck* provides on extragalactic sources, then describe some of the scientific conclusions drawn from the *Planck* measurements.

A radio astronomer's dream survey might have the following features: it would cover the entire sky; it would be conducted at many frequencies (including those difficult to reach from the ground); it would provide full Stokes polarization measurements; it would be repeated with several cadences; and it would be absolutely calibrated. This is precisely what the *Planck* mission has provided: all-sky surveys and catalogues of sources at nine frequencies, ∼28, 44, 70, 100, 143, 217, 353, 545 and 857 GHz, made over at least five independent surveys (eight surveys at the 3 lowest frequencies).

Planck has detected in its 5-6 lowest frequency bands the ∼1000 brightest radio sources, most of them extragalactic. It has also detected an even larger number of FIR sources, discussed by López-Caniego later in this volume. *Planck*'s measurements of compact sources are contained in the nine catalogues making up the PCCS2, one for each Planck frequency (see the detailed report by López-Caniego here).

I now briefly describe some results on extragalactic radio sources provided by the *Planck* surveys, and give references to the *Planck* papers that present detailed results. Perhaps the most fundamental result of the surveys is that *Planck* detected no new category of sources. Instead, it permitted refined counts of sources (Planck Collab. XXVI, 2015; see Fig. 1) and luminosity functions (Negrello *et al.*, 2013). Even early *Planck* results showed that source counts at all frequencies up to and including 217 GHz were dominated by flat-spectrum radio sources (blazars and other AGN; Planck Intermed. Results VII, 2013).

Planck also provided microwave spectra for hundreds of sources, including measurements at frequencies hard to reach from the ground. Fig. 2 shows an example, a source with both synchrotron emission and re-emission from hot dust (Lähteenmäki *et al.* 2015). At 28-70 GHz, there are 8 full-sky surveys, each lasting six months (and 5 surveys at 100 GHz and above). The repeated cadence has proven very useful for studies of radio source variability (see Chen *et al.* 2013 and Lähteenmäki *et al.* 2015).

Finally, *Planck* is absolutely calibrated to better than 1% precision at the frequencies of interest here using the CMB dipole induced by the satellite's yearly motion around

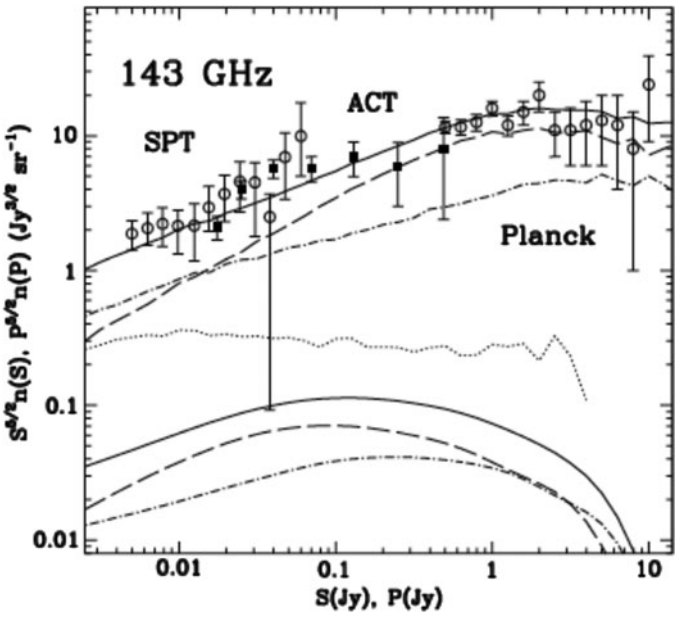

Figure 1. Source counts at 143 GHz; *Planck* supplies the counts at the bright end; the upper lines are models of source counts by Tucci *et al.* 2011, which fit the counts of Radio sources well. Their predictions of the counts of polarized sources are shown by the three lower curves.

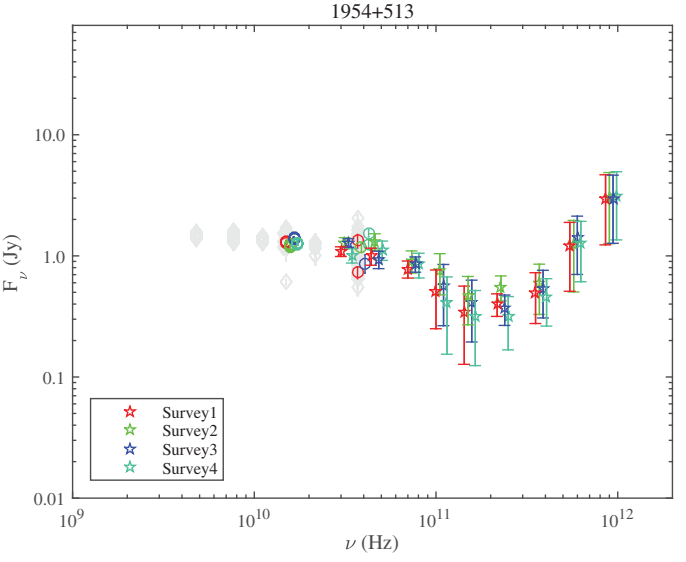

Figure 2. A sample *Planck* SED; the agreement from survey to survey show that this source does not measurably vary.

the Sun (Planck Collab. I 2015). This calibration has now been extended to ground based radio telescopes by direct comparison of *Planck* observations of sources and nearly simultaneous ground-based observations of the same sources (for the VLA and ATCA, see Partridge *et al.* 2015; for ACT, Louis *et al.* 2014). One example is shown in Fig. 3.

Much more can be done with *Planck* observations; we welcome wider use of *Planck* maps and catalogues by the radio astronomical community.

https://doi.org/10.1017/S174392131600449X Published online by Cambridge University Press

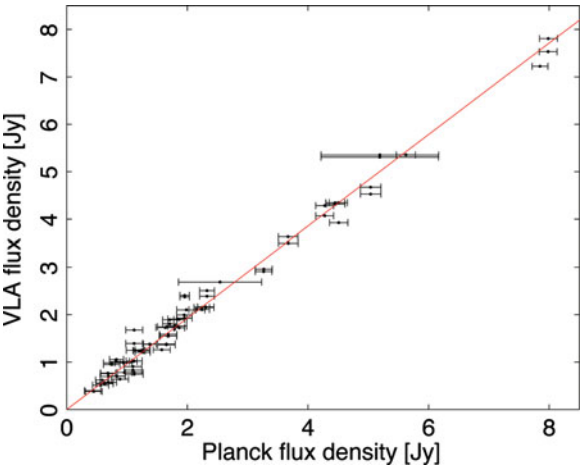

Figure 3. Comparison between *Planck* and VLA measurements at 28.45 GHz; scatter arises from variability. Slope = 0.964 ± 0.008; the VLA values run ∼ 3.6% below *Planck*'s, within the VLA uncertainty of ±5%.

References

Chen *et al.* 2013, *A&A*, 553, 107C
Lähteenmäki *et al.* 2015, in press at *A&A*
Louis *et al.* 2014, *JCAP* 7, 016
Negrello *et al.* 2013, *MNRAS* 429, 1309
Partridge *et al.* 2015, in press at *ApJ*
Planck Collab. I 2015, Planck Collab. XXVI, 2015, in press at *A&A*; arXiv:1502.01582 and arXiv:1507.02058
Planck Intermediate Results VII 2013, in press at *A&A*
Tucci, *et al.* 2011, *A&A* 533, A57

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