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Radio to infrared spectra of late-type galaxies with *Planck* and *WMAP* data

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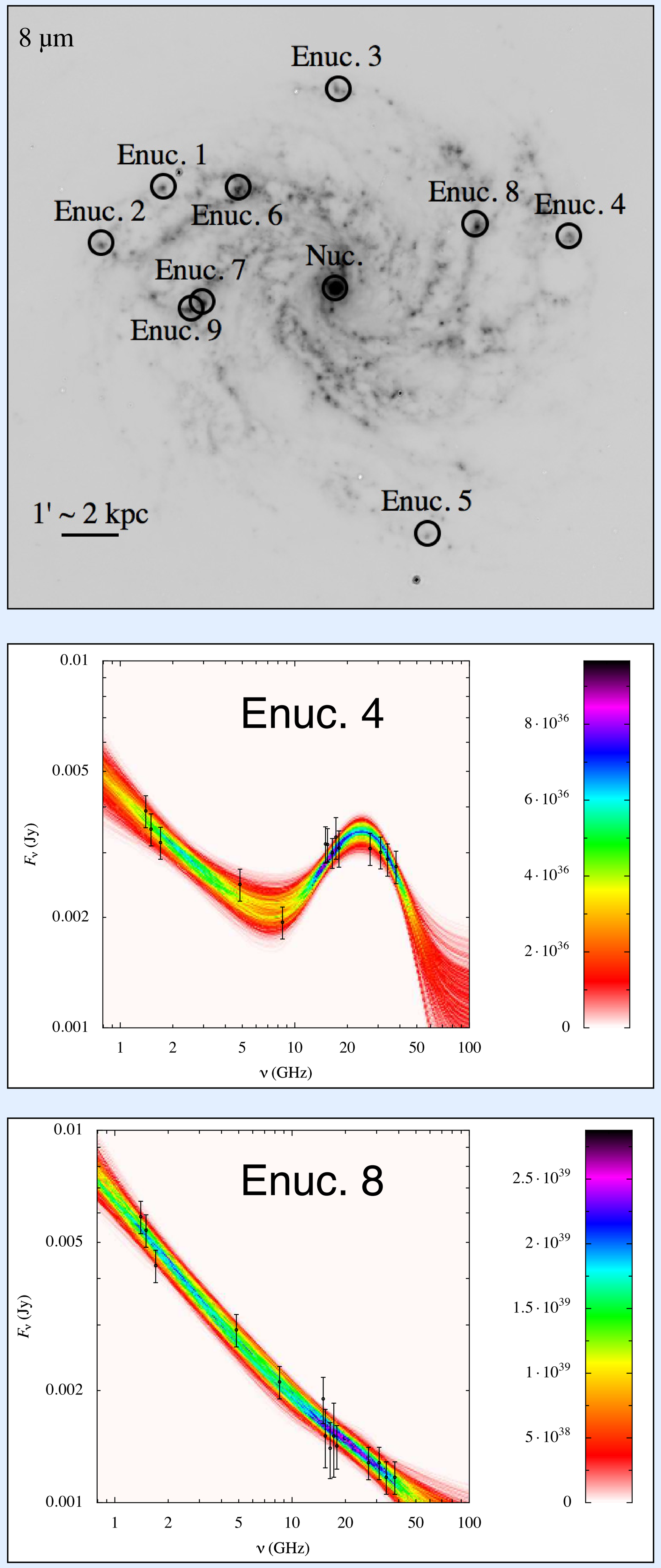

Figure 1: AME in NGC 6946 [1, 2]. Top: the regions observed, taken from [1]. Bottom: example spectra from AMI, taken from [2]. AME is only seen in Enuc. 4.

Method and Motivation

We use the Planck Early Release Compact Source Catalogue combined with WMAP and other archival measurements to construct continuum spectra of three nearby dusty star-forming galaxies: Messier 82, NGC 253 and NGC 4945. Our aims are to measure the **total emission of late type galaxies** to compare with the Milky Way, to **quantify the free-free emission** and to **calculate star formation rates** (SFR) from the free-free emission. We also **constrain Anomalous Microwave Emission** (AME) on a global basis, addressing the question of whether it is diffuse or patchy. Observations of NGC 6946 [1,2], shown in Fig. 1, only detect AME in 1/10 star-forming regions implying that it is clumpy not diffuse.

Thanks to Planck, for the **first time** we can accurately measure the **complete spectra** from radio to infrared. We carry out a least-squares fit to the spectra using a combination of simple synchrotron, free-free and thermal dust models, and look for evidence of AME. (see Fig. 2)

Results

- We find **cold dust emission of 19-25K** for the three galaxies, in agreement with the statistical Planck results for nearby galaxies [3].
- The radio spectra of all 3 galaxies are **consistent with steep synchrotron emission**, with a **significant amount of free-free emission** required to explain the Planck and WMAP data.
- The SFR based on free-free emission (calculated via formulae from [4]) better agrees with that from the non-thermal emission than e.g. [5], with SFR in $M_\odot$/yr based on (synchrotron | free-free) emission of (2.6 | 3.0) in M82, (1.3 | 2.2) in NGC253 and (2.7 | 2.9) in NGC4945.
- We find that the **AME amplitude is lower than expectations** based on the ratio of far infrared to AME from the Galaxy (1/3000 of the 100 μm emission, [6]). E.g. for M82, 0.36 Jy would be expected, but <0.15 Jy (3σ) is seen.
- This **implies that AME is indeed clumpy** rather than diffuse. However, the shape of the spectrum of NGC 4945 does hint at the presence of AME with a peak around 30 GHz.

Future Planck data will let us look more closely at these galaxies and to extend the analysis to many more galaxies. Additional radio continuum and recombination line data would pin down the free-free and synchrotron emission amplitudes and improve the limits on AME.

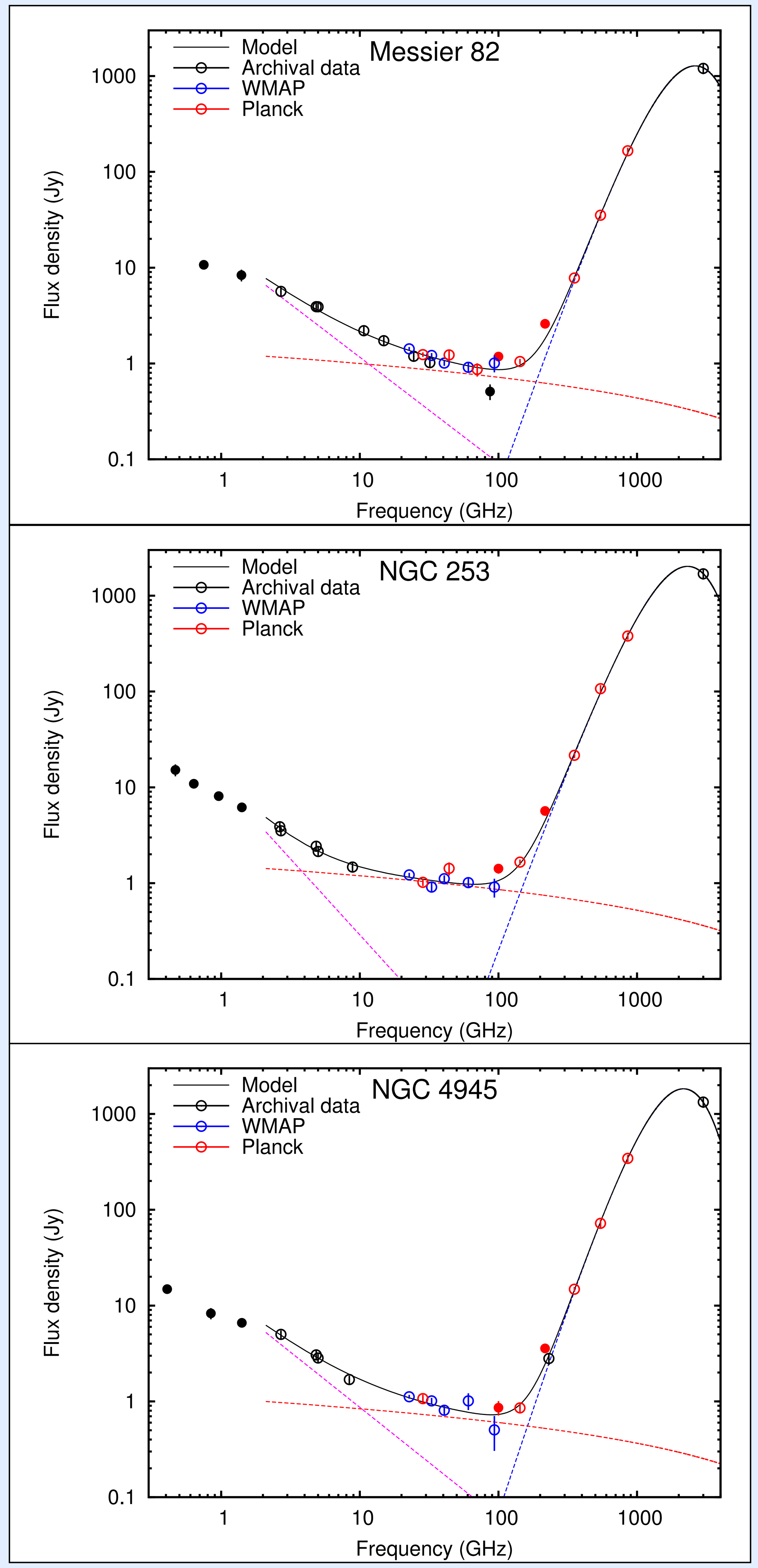

Figure 2: Spectra for M82, NGC 253 and NGC 4945. Best fit lines for synchrotron (magenta), free-free (red) and thermal dust (blue) are shown.

[1] Murphy et al. (2010), ApJL, 709, L108
[2] Scaife et al. (2010), MNRAS, 406, L45
[3] Planck collaboration et al. (2011), A&A, 536, 16
[4] Condon (1992), ARA&A, 30, 575
[5] Niklas et al. (1997), A&A, 322, 19
[6] Todorovic et al. (2010), MNRAS, 406, 1629