Accuracy of the Stevens-Reynolds PKS B1934-638 flux scale using MeerKAT - a comparison from 0.5 to 3.3 GHz

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We briefly detail a comparison of flux scales transferred from the Reynolds [1994] and Partridge et al.[1] [2016] scales (used for the Compact Array and MeerKAT) onto the Perley-Butler [2017] scale. Errors between the two scales are critical to quantify when deriving e.g. spectral index maps and integrated power measurements.

We have already quantified contributions from off-axis field sources at low frequencies for MeerKAT, as well as errors between the ATCA and Perley-Butler scales in M2600-0000-043. Differences between the two scales are noted in that memo as up to 7% at the lowest frequencies of UHF band and a much smaller error of around 2% in L-band, based on a comparison between the transferred scale to 3C286 and what is documented in Perley-Butler [2017] from long term observation. We now extend this quantification on the differences using the S Band system of MeerKAT.

We used the following databases under the 3C286 - Lunar polarization calibration project under proposals COM-20210505-BH-01 and EXT-20220902-BH-01, see Table 1.

SB ID	Observation time	Band
20210622-0005	2021-06-22 17:01:14.157 to 2021-06-22 21:23:36.259 UTC	UHF wide
20210522-0015	2021-05-22 22:06:09.144 to 2021-05-22 22:33:29.455 UTC	L wide
20210818-0008	2021-08-18 13:31:15.086 to 2021-08-18 17:28:13.071 UTC	L wide
20210626-0017	2021-06-26 19:11:38.470 to 2021-06-26 23:35:31.134 UTC	S0 wide
20220902-0008	2022-09-02 11:55:34.735 to 2022-09-02 15:57:53.429 UTC	S3 wide

Table 1: Data used for this analysis.

In the cases of UHF and L-band we use the Reynolds 1994 scale with full field models, as derived in M2600-0000-043 for MeerKAT, and transfer the gain amplitude and amplitude normalized bandpass onto 3C286 before refining phases for 3C286 through self-calibration using WSClean [Offringa et al. 2014] and CASA [McMullin et al. 2007].

With the impact of field source fluxes limited by the smaller antenna far field beam in S0 and S3 bands, we assume a point source model for PKS B1934-638 based on the updated

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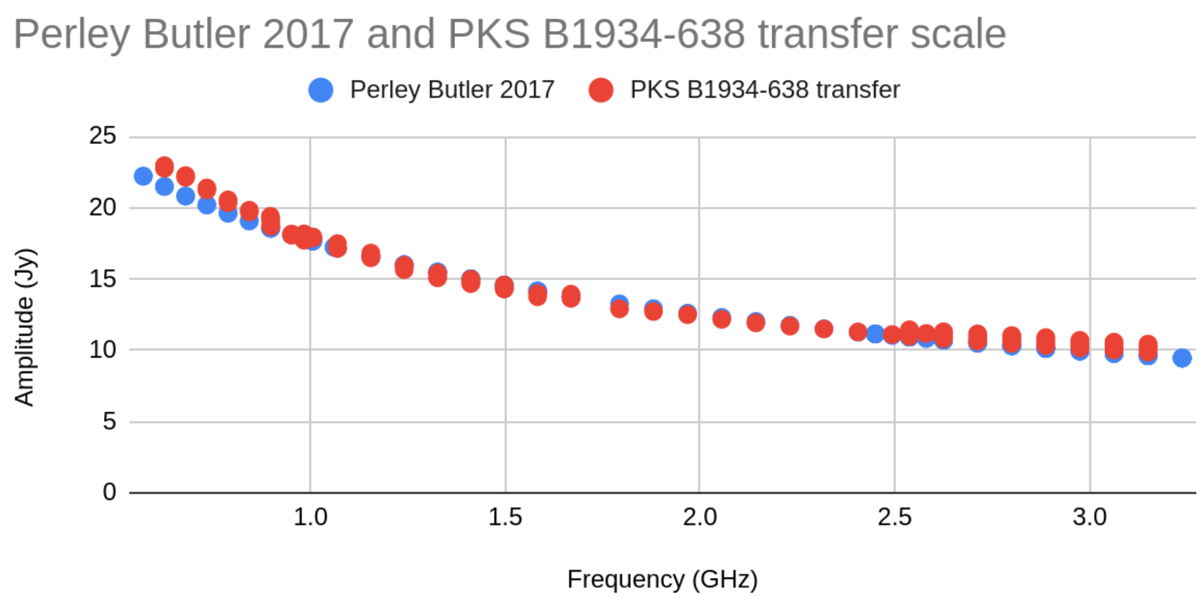
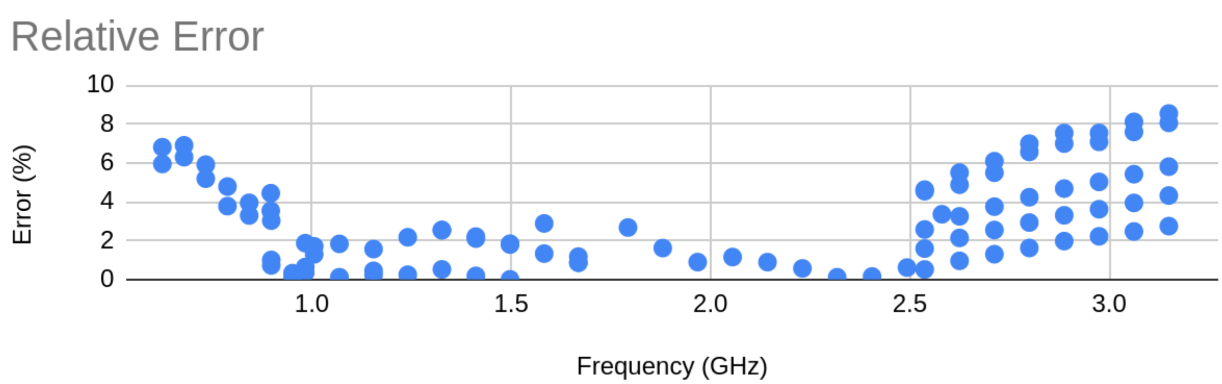
[1] The Partridge et al. scale is referred to as “Stevens-Reynolds 2016” inside of CASA setjy

high-frequency model from Partridge [2016]. The flux is measured directly from the imaging bands cleaned with WSClean in Multi-Frequency-Synthesis cleaning mode.

The flux scale and the relative errors between the PKS B1934-638 transferred scale, as measured on 3C286 and compared to Perley-Butler [2017] are shown in Figure 1.



(a)



(b)

Figure 1: (a) Transfer scale measurement and Perley-Butler [2017] scale. (b) Error between scales quantified by multiple measurements.

We note that the S3 observation had significant gain variability on multiple antennae, most likely due to residual pointing problems looking in slope changes in the bandpass of affected antennae. The spread in the relative error here is likely due mostly due to to this effect. The average error at the highest frequencies are at the 5% level while UHF consistently has an error of around 7% - matching very well the flux scale error estimates provided by M2600-0000-043.

The spread in the multi-scan S3 observation is reasonably consistent with intra-observation residual gain errors are usually of around 1-2%, as seen in M2600-0000-043 (figure 6, rev. C). Although the error between the scales is worse at UHF and S3 it is still well within the 10% error margin usually assumed by authors. Given that the same frequency-based effects are seen at UHF and S3 bands it is likely that the curvature terms fitted for this Gigahertz-Peaked Source is slightly wrong in current models.

With improved pointing performance on the S-band system the gain errors seen may eventually be reduced at highest frequencies. This note serves as a first pass estimation for early science observations planned for the S-band system.

END

References

Partridge, B., et al. "Absolute calibration of the radio astronomy flux density scale at 22 to 43 GHz using Planck." *The Astrophysical Journal* 821.1 (2016): 61.

Perley, Richard A., and Bryan J. Butler. "An accurate flux density scale from 50 MHz to 50 GHz." *The Astrophysical Journal Supplement Series* 230.1 (2017): 7.

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