ALMA Science

What is meant by imaging dynamic range?

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Images made from interferometric data are usually subject to calibration errors that limit the quality of the image. Errors remaining after phase referencing are most common and move flux around the map, lowering the peak flux density and increasing the image rms. One measure of the quality of an image is the dynamic range, where this is defined as the ratio of the peak flux to the rms. If the source is bright enough, self-calibration can be used to correct for these errors (phase and amplitude) and thus to increase the image dynamic range towards the expected value.

However, it is not always possible to achieve the theoretical dynamic range i.e. that corresponding to the actual peak source flux divided by the rms expected based on the observing time, bandwidth and system temperature. Any errors during deconvolution (due to perhaps poor u,v coverage or errors remaining after self-calibration) will leave residuals of the dirty beam in the cleaned image, these being larger for brighter sources. These residuals prevent the theoretical rms from being reached and thus bright sources set a limit on the maximum achievable dynamic range.

As the residuals have structure, the non-thermal component of the rms is not always uniform throughout an image, and therefore the dynamic range will not be either. The achievable dynamic range very close to a bright source will be less than the ratio of the peak flux to the rms measured far away from the source. In cases where high dynamic range is critical for science, the .psf and .residual images should both be carefully considered.

Note that the limiting source need not be in the main field of view - sources in the sidelobes of the antenna beam can also place residuals across the region being imaged. For ALMA, imaging dynamic ranges are expected to reach up to around 100 for the lower frequency bands and closer to 50 for Bands 9 and 10.