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AU Mic:
The Journey Begins

by

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Table 1: Observation Information

	26 March 2014	18 August 2014	24 June 2015
Antennas:	32	35	37
Baselines (m):	14–437	20–1268	30–1431
On-source time (min):	35	35	33
Flux calibrator:	Titan	J2056-472	Titan
Bandpass calibrator:	J1924-2914	J2056-4714	J1924-2914
Phase calibrator:	J2101-2933	J2101-2933	J2056-3208
pwv (mm):	0.6	1.6	0.7

AU Mic was observed with ALMA on three dates: 26 March 2014, 18 August 2014, and 24 June 2015. All observations were configured with four spectral windows, and employed ALMA's 12m antennas and Band 7 receivers. Within each observation AU Mic was observed in seven-minute segments.[1] One spectral window was centered around the CO $J = (2-1)$ transition at a frequency of 230.538001 GHz, with a total bandwidth of 1.875 GHz and a channel spacing of 488 kHz. The remaining three spectral windows were configured to detect continuum emission with central frequencies of 228.5, 213.5, and 216.0 GHz, total bandwidths of 2 GHz, and channel spacings of 15.6 MHz.

Information regarding the three observation dates can be found in Table 1. The short-baseline March observation provides information about AU Mic's disk on large spatial scales; in contrast, the subsequent long-baseline August observation was intended to trace the small-scale structure of the disk. The quality of the gain transfer for the August observation was tested using observations of the quasar J2057-3734. Due to subpar[2] quality, the August data were supplemented with a second night of long-baseline observations in June 2015; this time the quasar J2101-2933 was used to assess the gain transfer quality. During the last segment

[1]Extraneous?
[2]too informal?

Table 2: Subtracted point-source fluxes

Time (UTC)	Point-source Flux (μJy)
03:45:0–04:20:0 (no flare)	$(4.1 \pm 0.2) \times 10^2$
4:23:38–4:24:00	$(9.2 \pm 1.7) \times 10^2$
4:24:00–4:25:00	$(1.146 \pm 0.010) \times 10^4$
4:25:00–4:26:00	$(3.59 \pm 0.10) \times 10^3$
4:26:00–4:27:00	$(1.58 \pm 0.10) \times 10^3$
4:27:00–4:28:00	$(4.50 \pm 1.0) \times 10^2$
4:28:00–4:29:00	$(4.60 \pm 1.0) \times 10^2$
4:29:00–4:29:58	$(5.20 \pm 1.0) \times 10^2$

of the June observation (04:23:38-04:29:58 UT), the host star flared. While we initially fit and subtracted off the flare fluxes (see Table 2), it was ultimately decided that the data taken during the flare was too problematic to be included in our analysis.

Calibration, reduction, and imaging were carried out using the `CASA` and `MIRIAD` software packages. Standard ALMA reduction scripts were applied to the datasets: phase calibration was accomplished via water vapor radiometry tables, and system temperature calibrations were performed to account for variations in instrument and weather conditions. Flux and bandpass calibrations were subsequently applied.

The authors travelled to the NRAO facility in Charlottesville, VA in October 2015 to further process the data in `CASA`. For each observation, an elliptical gaussian was fit with the task `imfit` to a small region around the star in the sky plane. The equatorial coordinates of the the model gaussian centroid were then used to define the star position, which was uncertain due to AU Mic's high proper motion: each dataset was phase shifted using the task `fixvis` so that the pointing center of the data was the same as the fitted star position.

The June date pointing center, defined by the centroid of the elliptical gaussian fit to the star, was visibly offset from the surrounding disk; this could be explained if the flare referenced above were not symmetric with respect to the star. The offset was remedied by redefining the pointing center as follows. Because the star is known to be located at the center of the disk, we can use information provided by the brightness distribution of the disk to infer the star position. We do so by selecting the brightest pixel on each side of the disk from the clean component map (the `.model` file produced by `tclean`), and redefining the star/pointing center as the mean of the two pixel positions. This yields offsets of $(0.01'', -0.05'')$ for the March observation, $(0.01'', 0.00'')$ for the August observation, and $(0.00'', 0.09'')$ for the June observation. Given the good agreement between the calculated star position and the image center for the two non-flare dates (March and August), we conclude that the 'pixel' method represents a viable way to accurately determine star position. We apply this correction and redefine the image center via `fixvis`. For consistency, we apply the phase shift to all three dates.

Due to the high proper motion of AU Mic, the pointing centers of the three dates differ by a not-insignificant amount. When datasets with different pointing centers are cleaned together with `tclean`, the pointing center of the first dataset is taken as the new pointing center, and the data are combined in in the uv plane with each subsequent dataset offset from the first as given by their relative pointing centers. In the case of AU Mic, this leads to an image of the disk composed of three observations offset with respect to each other. To remedy this, we use the task `concat`, which combines datasets with their pointing centers aligned so long as the pointing centers do not differ by more than the value of `dirtol`. We set `dirtol` to $2''$, a value larger than AU Mic's proper motion over ALMA's ~ 1 year observation baselines.