HERA118
Received: 10 Nov 2022

The Effect of Fallen Conduits on Autocorrelation Spectra

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10 November 2022

ABSTRACT

During our site visit last summer (25 June - 2 July, 2022) we conducted a visual survey of all the HERA antennas. We identified 13 antennas for which the conduit had fallen from its design position inside the feed or was missing. For six of these antennas we have autocorrelation spectra from an observing run (4 July 2022) shortly after our return. No data had been acquired during H5C for the other seven antennas. Five of the six antennas show bandpass shapes that are very different from nominal. One apparently has broken fibers in both polarizations. Another apparently has a broken fiber in one polarization, and a somewhat unusual bandpass shape in the other polarization. For the sixth antenna, the absence of a conduit does not seem to have a discernible effect on the bandpass shape. Through our inspection of many the feeds in the array we determined that the conduits were not installed in the feeds according to design. Rather, the conduits are held in place with cable ties, and we expect that more will work their way loose and drop or fall to the ground. Understanding the effects of a fallen conduit on the autocorrelation spectra should help us identify in the future antennas that require re-installation of the conduits.

1. Introduction

In the HERA antennas, three cables run from the Front End Module to the node, first passing through the center of the feed and down to the center of the hub. These three cables are the Cat7 cable, the coaxial cable, and the fiber (the latter is actually two fibers, one for each polarization). The Cat7 cable and the coaxial cable are wrapped in metal braid. At the time of their installation, the cables are inserted into a dielectric conduit that separates the cables from the conducting surfaces of the feed blades. Figure 1 shows the cables running through the conduit. Details of the cable design can be found in Fagnoni et al. 2021; a video with instructions for cable installation can be found at https://www.youtube.com/watch?v=UQ-XB4N-3pc. We are interested in assessing the effect of missing conduits on the data so that we can recognize the issue if it continues to occur in the future.

Fig. 1.— A HERA feed viewed from below. The conduit is in the cavity formed by the four feed blades, and three cables can be seen emerging from the bottom of the conduit.

2. Antennas with Fallen or Missing Conduits

During the period from 25 June 2022 through 1 July 2022 we conducted a visual survey of all the HERA antennas. We identified thirteen antennas with fallen or missing conduits. Table 1 lists these antennas, their node membership, whether H5C autocorrelation are available, and the comments recorded at the time of the survey. As noted in the Table, the feed for antenna 134 was resting on the hub, and we exclude this antenna from further discussion in this memo. For all the other antennas, the feed was raised. We observed quite a bit of variation in feed heights across the array, so it should not be assumed that any of these feeds are necessarily at the nominal design height of 4.406 meters above the hub (as measured from the top of the plywood of the feed-positioning jig). We examined the "auto_metrics_inspect" and "antenna_report" HERA daily notebooks[1] and found that only six of these antennas have returned autocorrelation data during H5C. Figure 2 shows the auto_metrics_inspect plots for these six antennas for data taken on JD 2459765 (4 July 2022).

3. Discussion

The autocorrelation spectra of antennas 166, 167, and 190 show very unusual bandpass shapes that are very likely to be flagged by an analysis pipeline. The NN polarization of Antenna 52 has a very low power level. This is frequently seen when the fiber is broken, and

[1]These HERA daily notebooks are available at https://github.com/HERA-Team/H5C_Notebooks

Antenna	Node	H5C Data?	Comment
22	6	No	Conduit suspended about one foot below feed
50	3	Yes	Conduit on hub
52	3	Yes	Conduit on hub
59	5	No	Conduit on hub
60	5	No	Conduit on hub
75	5	No	Conduit on hub
95	11	No	Conduit slipped about 2 inches down
134	11	No	Feed on hub and conduit fallen onto hub
155	12	Yes	Conduit falling
166	14	Yes	Conduit on hub
167	15	Yes	Conduit missing
190	15	Yes	Conduit suspended about one foot below feed
240	19	No	Conduit suspended very low

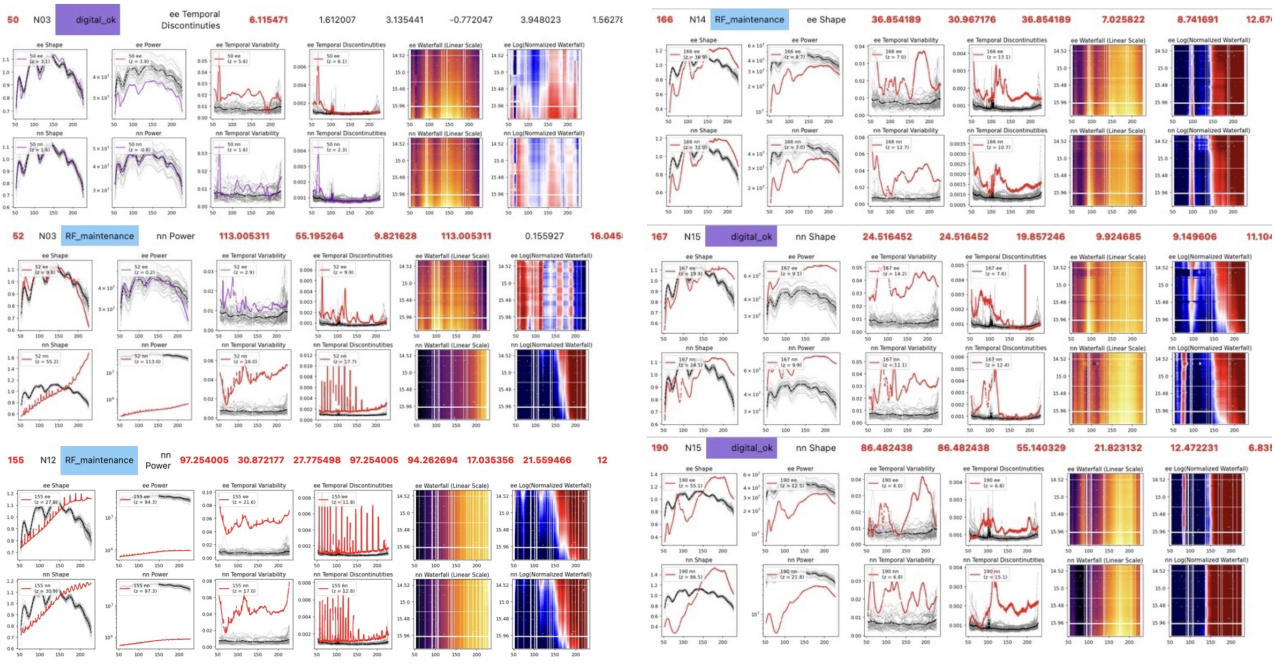

Fig. 2.— Auto_metrics_inspect panels for antennas without conduits for which there is H5C data. These data were taken on J2459765 (4 July 2022)

we suspect this is the case for this antenna-polarization. Antenna 52 has the "yellow fiber," which is the less robust of the two types of fiber in the HERA array. Since much of the yellow fiber is visibly damaged, it would not be surprising to find such damage in Antenna 52. The bandpass shape of the EE polarization autocorrelation spectrum of Antenna 52 is unusual, and we suspect would also likely be flagged by the RTP pipeline. Surprisingly, the bandpass shape of Antenna 50 appears nominal in both polarizations. One would expect that contact between the outer conductor of a cable and the conducting surface of the feed blades would affect the electromagnetic performance of the feed-dish system. We suspect that for the case of Antenna 50, there is no contact between the cables and the feed blades, and for the other antennas some such contact is responsible for the changed bandpass shapes. It is also possible for the height of the feed to affect bandpass shape. However, we find both experimentally and theoretically (see Hewitt et al. 2021) that the effects of feed height are much smaller than the large variations we see when a conduit falls.

While the fact that five out of six antennas with fallen feeds show bandpasses that are very far from nominal is suggestive, this does not of course prove cause and effect. On June 28 we opened commissioning issue #742 requesting that the conduits for these antennas be reinstalled. The issue was closed on 18 October.

As noted in the instructional video referenced above, the design of the conduit called for it to be held in place by two dielectric blocks, which in turn were to be held in place by plastic screws. Site personnel report that the plastic screws frequently broke, and so they instead used two crossed cable ties to hold the conduit in place. Our observation is that it is possible for the conduit to work its way past the cable ties, and when it does so it drops part way down the cables or it drops all the way to the hub. This is undesirable. We believe that the plastic screws will not break if they are installed by hand, rather than with a power drill. We recommend, therefore, that as new feeds are installed and as fallen conduits are replaced that the conduits be secured with the blocks and plastic screws as originally planned.

We further recommend that autocorrelation bandpass shapes be monitored in the future, and for those antennas that show significant anomalies in bandpass shape a visual inspection of the conduit be ca rried out.

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