A Survey of Interplanetary Small Flux Ropes at Mercury

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Small flux ropes (SFRs) are interplanetary magnetic flux ropes with durations from a few minutes to a few hours. We have built a comprehensive catalog of SFRs at Mercury using magnetometer data from the orbital phase of the MESSENGER mission (2011-2015). In the absence of solar wind plasma measurements, we developed strict identification criteria for SFRs in the magnetometer observations, including conducting force-free field fits for each flux rope. We identified a total of 48 events that met our strict criteria, with events ranging in duration from 2.5 minutes to 4 hours. Using superposed epoch analysis, we obtained the generic SFR magnetic field profile at Mercury. Due to the large variation in Mercury's heliocentric distance (0.31-0.47 AU), we split the data into two distance bins. We found that the average SFR profile is more symmetric "farther from the Sun", in line with the idea that SFRs form closer to the Sun and undergo a relaxation process in the solar wind. Based on this result, as well as the SFR durations and the magnetic field strength fall-off with heliocentric distance, we infer that the SFRs observed at Mercury are expanding as they propagate with the solar wind. We also determined that the SFR occurrence frequency is nearly four times as high at Mercury as for similarly detected events at 1 AU. Most interestingly, we found two SFR populations in our dataset, one likely generated in a quasi-periodic formation process near the heliospheric current sheet, and the other formed away from the current sheet in isolated events.