

Exascale Real-Time Radio Frequency Interference Mitigation

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Published in:

Exascale Radio Astronomy, AAS Topical Conference Series Vol. 2. Proceedings of the conference held 30 March - 4 April, 2014 in Monterey, California. Bulletin of the American Astronomical Society, Vol. 46, #3, #403.01

Publication Date: 04/2014

Abstract

Radio Frequency Interference (RFI) mitigation is extremely important to take advantage of the vastly improved bandwidth, sensitivity, and field-of-view of exascale telescopes. For current instruments, RFI mitigation is typically done offline, and in some cases (partially) manually. At the same time, it is clear that due to the high bandwidth requirements, RFI mitigation will have to be done automatically, and in real-time, for exascale instruments. In general, real-time RFI mitigation will be less precise than offline approaches. Due to memory constraints, there is much less data to work with, typically only in the order of one second or less, as opposed to the entire observation. In addition, we can record only limited statistics of the past. Moreover, we will typically have only few frequency channels locally available at each compute core. Finally, the amount of processing that can be spent on RFI mitigation is extremely limited due to computing and power constraints. Nevertheless, there are potential benefits as well, which include the possibility of working on higher time and frequency resolutions before any integration is done, leading to more accurate results. Most importantly, we can remove RFI before beam forming, which combines data from all receivers. The RFI that is present in the data streams from the separate receivers is also combined, effectively taking the union of all RFI. Thus, the RFI from all receivers pollutes all beams. Therefore, it is essential to do real-time RFI mitigation before the beam former. This is particularly important for pulsar surveys, for instance. modes. Although our techniques are generic, we describe how we implemented real-time RFI mitigation for one of the SKA pathfinders: The Low Frequency Array (LOFAR). The RFI mitigation algorithms and operations we introduce here are extremely fast, and the computational requirements scale linearly in the number of samples and frequency channels. We evaluate the quality of the algorithms with real LOFAR pulsar observations. By comparing the signal-to-noise ratios of the folded pulse profiles, we can quantitatively compare the impact of real-time RFI mitigation, and compare different algorithms.