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Excavation in the Sky: Historical Inference in Astronomy

Philosophers have discussed how historical sciences present different subject matter, epistemic goals, challenges, and methodologies from typical experimental sciences and non-historical observational sciences. This philosophical framework is valuable for both identifying previously neglected historical aspects in many other sciences and further crystalizing its own concepts and theories. Astronomy in the last 10 decades has gradually unveiled its historical character from the stereotype of a physical-mathematical science. With this observation, I borrow the philosophical framework of historical sciences to analyze some recent astronomical practices. This synthesis offers contributions to both sides: a more adequate description of the epistemology and methodology of astronomy, and a reconsideration of the concept of "trace" in historical sciences in general. First, I point out that astronomy shares with historical sciences the study of token events and extremely long-term evolutionary processes, together with many epistemic challenges. I further argue that the method of historical reconstruction and the acquaintance with the history of specific celestial objects play a crucial role in solving many problems in astronomy, and they constitute a crucial aspect of how astronomers utilize the idea of the "cosmic laboratory". Second, astronomy faces a typical difficulty in identifying traces and connecting them to past events. This elicits a more careful understanding of the notion of "trace" and more intricate processes of identifying them from raw data and making inferences from them. I present how astronomers address this difficulty using a method called "phase-space clustering" in the reconstruction of the Milky Way merger history. I point out that the identification of traces is only gradually achieved through iterations between data-driven approaches and theory-driven approaches. This also requires the synthesis of studies of multiple relevant historical events and the cross-validation between diverse datasets.