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# Editorial: Coronal Magnetometry

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**Editorial on the Research Topic**

**Coronal Magnetometry**

Magnetism defines the complex and dynamic solar corona. It determines the magnetic loop structure that dominates images of the corona, and stores the energy necessary to drive coronal eruptive phenomena and flare explosions. At great heights the corona transitions into the ever-outflowing solar wind, whose speed and three-dimensional morphology are controlled by the global coronal magnetic field. Coronal magnetism is thus at the heart of any understanding of the nature of the corona, and essential for predictive capability of how the Sun affects the Earth.

Such an understanding will ultimately come from knowing the time-evolving vector magnetic field throughout the solar corona. Given this knowledge, it becomes possible to determine where magnetic free energy is stored, what triggers the eruptive events that release this energy, where solar energetic particles are accelerated and how they propagate, and how coronal mass ejection (CME) internal magnetic structure evolves in response to interactions with the surrounding corona and solar wind.

Until recently, our knowledge of magnetism in the corona was primarily limited to extrapolations of solar surface observations in conjunction with purely morphological coronal observations. There are several reasons that obtaining more direct observations of the coronal magnetic field is difficult; foremost among them is that the corona is optically thin and relatively dim compared to the solar disk. However, current and planned coronal polarimetric measurements are changing this paradigm, making the development of coronal magnetometric techiques a priority.

Coronal magnetometry is a subject that requires a concerted effort to draw together the different strands of research happening around the world. Each method provides some information about the field, but none of them can be used to determine the full 3D field structure in the full volume of the corona. Thus, we need to combine them to understand the full picture. The purpose of this Frontiers Research Topic on Coronal Magnetometry is to provide a forum for comparing and coordinating these research methods. We now briefly summarize the papers it contains.

A key development of recent years has been the availability of coronal polarimetric measurements, in particular at visible and infrared wavelengths. Dima et al. presents a method for combining linear-polarization measurements from near-infrared permitted and forbidden coronal emission lines to calculate the coronal vector magnetic field. Raouafi et al. similarly argues for multiwavelength linear-polarization diagnostics, using forward modeling of global MHD models to demonstrate the complementary diagnostic power of ultraviolet and infrared lines. Moving away from polarimetric measurements, Bemporad et al. discusses the extent to which the magnetic field strength of CMEs in the outer corona might be deduced from white-light and ultraviolet observations assumed to correspond to shock fronts.

Observations of both coronal morphologies and thermal plasma properties contribute clues to the nature of the underlying magnetic structure. Jibben et al. presents a case study, and Bąk-Stęślicka et al. presents a statistical analysis of thermal and velocity structure within quiescent

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(non-erupting) coronal prominence cavities, finding evidence for a magnetic flux-rope topology. Guennou et al. uses solar-rotational tomography to characterize the evolution of a pseudostreamer-cavity system and its thermodynamic properties. Kramar et al. uses tomography to model the 3D density and emissivity of the global corona for one rotation, and compares morphological features to a potential-field model of the rotation.

The ultimate goal is to build a 3D global coronal magnetic field. To do so will necessarily draw upon the observations and diagnostics described above, but also is likely to require the explicit utilization of boundary-driven numerical models. Jiang et al. presents an MHD model driven by the time-evolving photospheric boundary vector magnetic field, in the presence of a stratified atmosphere. Zhang and Feng describes how such MHD simulations must be kept divergence-free. Jibben et al. presents a nonlinear-force-free-field model based on the photospheric line-of-sight magnetic boundary, with currents added to match coronal observations of a prominence cavity system. Forward modelng then allows direct comparison to coronal polarimetric data.

Methodologies for drawing together models and observations in an efficient fashion need to be developed, including forward and inverse techniques. Gibson et al. presents the FORWARD software suite for model-data comparison, and discusses how multiwavelength data might be used to constrain models of the physical state of the corona. Van Doorsselaere et al. presents the FoMo software for forward modeling of emission from coronal plasma, which has been applied to the study of coronal wave models in EUV and radio gyrosynchrotron emission. Dalmasse et al. presents a new Radial-basis-function Optimization Approximation Method (ROAM) for obtaining orders-of-magnitude increases in speed vs a full grid search of parameter space, and applies it to fitting synthetic polarimetric data obtained through forward modeling a magnetic-flux-rope model.

Finally, new telescopes are needed to fully realize the potential of coronal magnetometry. Limitations of ground-based coronal polarimetric observations might be overcome by a balloon-borne mission, such as the Waves and Magnetism in the Solar Atmosphere (WAMIS) investigation, consisting of a 20 cm coronagraph with a visible-IR spectropolarimeter focal plane assembly (Ko et al.) Difficulties measuring the weak circular polarization signal in the corona require larger aperture telescopes; alternatively, technological advances may substantially increase the efficiency of coronal spectropolarimeters, as described for the mxCSM, a proposed 100-slit, 6-Wavelength wide-field coronal spectropolarimeter (Lin).

In conclusion, the field of coronal magnetometry is a young one, with new observations, models, and methodologies continuing to be developed, and with rich potential for substantial scientific discovery over the next decade.

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