Preface

Twenty years ago, the first *Statistical Challenges in Modern Astronomy* (SCMA) conference was held at Penn State University. Serving as a gathering of two scholarly communities with common interests, SCMA meetings have been held every 5 years for cross-disciplinary discussions of methodological issues arising in astronomical research. These are the proceedings of the fifth SCMA conference held in June 2011. While some of the topics are the similar as those in the 1991 meeting, the level of sophistication and accomplishment has enormously increased. Astronomers and statisticians worldwide have developed collaborations to address some of the most challenging and important problems facing astronomy today. These involve data mining enormous datasets from widefield surveys obtained with major new telescope systems, fitting of cosmological and other astrophysical models to complex datasets, and studying the temporal behaviors of innumerable variable objects in the sky. Bayesian inference has gained considerable momentum in astrophysical model fitting. These advanced methods are gaining attention outside of the world of expert astrostatisticians, as the broad astronomical community realize that twenty-first century science goals can not be achieved with nineteenth and twentieth century statistical methods. At SCMA V, both young and experienced astrostatisticians presented work and engaged in discussions on how these problems can be best addressed.

The proceedings are divided into six sections; most invited talks are followed by invited commentaries by scholars in the other field. The volume begins with five talks on *Statistics in Cosmology* demonstrating significant recent accomplishments in this most-important field of astronomy and astrophysics. Modern accomplishments of modern quantitative cosmology rely heavily on sophisticated statistical analysis of large datasets. Topics reviewed include likelihood-free estimation of quasar luminosity functions (Schaefer and Freeman), estimation of galaxy photometric redshifts and quantification of voids in galaxy Large-Scale Structure (Wandelt), inference based on comparing data to cosmological simulations (Higdon), likelihood estimation of gravitational lensing of the cosmic microwave background (CMB) radiation (Anderes), and application of needlets to cosmic microwave background studies (Marinucci).

The second section provides a sampling of the growing applications of *Bayesian Analysis Across Astronomy*. Here we have both invited reviews by senior researchers, and a sampling of the many works by younger researchers. The reviews discuss Bayesian models constructed to model galaxy star formation histories (Weinberg), model selection within the consensus ΛCDM cosmological model family (Trotta), and measurement errors in astronomical regression and density estimation problems (Kelly). The shorter talks treat asteroseismology (Benomar), event detection in time series (Blocker and Protopapas), reverberation mapping in active galactic nuclei (Brewer), modeling of Poisson images (Guglielmetti et al.), treatment of instrument calibration errors (Kashyap et al.), modeling of Type Ia supernova data (Mandel), and faint source flux estimation (Switzer et al.). Advanced methods for hierarchical modeling and Monte Carlo Markov Chain computational techniques are discussed in many of these talks and associated commentaries.

The third section of the proceedings address the use of modern techniques techniques of *Data Mining and Astroinformatics* for the analysis of massive datasets emerging from many new observatories. Compressive sensing, an extension of wavelet analysis, is very promising for many problems (Starck). Diffusion maps can treat non-linear structures in high-dimensional datasets (Lee and Freeman). Nearest neighbor techniques are used for outlier detection in megadatasets (Borne and Vedachalam). Bayesian approaches can help cross-identification of sources between astronomical catalogs (Budavári). Likelihood-based data compression can assist parameter estimation in large datasets (Jimenez).

The fourth section considers challenges arising in astronomical *Image and Time Series Analysis*. Techniques of mathematical morphology are applied to classifying sunspots (Stenning et al.). Realistic images are simulated using knowledge of celestial populations and telescope characteristics (Connolly et al.). Structure recognition algorithms are discussed for three-dimensional astronomical datacubes (Rosolowsky). The problem of locating faint transient sources in multiepoch image datasets is addressed by controlling the False Discovery Rate (Clements et al.). Wavelets are a valuable tool for modeling irregularly spaced time series (Mondal and Percival).

The fifth section provides perspectives on *The Future of Astrostatistics*. The field is gaining a presence in international organizations (Hilbe). The public domain **R** statistical computing environment is a very promising new software environment to implement existing and develop new statistical analyses for astronomical research (Tierney). A Panel Discussion discusses various aspects of astrostatistical practice and research for the coming decade (van Dyk, Feigelson, Loredo, Scargle). The final section of the proceedings gives brief presentations of the contributed posters. Many fascinating problems and sophisticated statistical methods are described.

The work of many individuals and organizations contributed to the success of the SCMA V conference. The invited speakers and cross-disciplinary commentators were the central pillar of the conference, and we are grateful for their presentations and manuscripts. Staff in the Departments of Statistics and Astronomy and Astrophysics provided administrative support. Funding support for the conference was provided by the two departments, Penn State's Eberly College of Science,

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