The Era of Bright (Star) Astronomy

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Wide field surveys and time domain astronomy will be the lynchpin of astronomical research in the next decade. All-sky astrometric surveys (Gaia) will complement photometric surveys from both the ground and space (e.g., TESS, ZTF), aided by multi-object multi-epoch spectroscopic surveys (e.g., DESI, Sloan 5). The symphony of surveys will reach a crescendo in the mid-2020s as LSST begins full science operations, delivering unprecedented volumes of data to the community.

In our view there is a strong "photometric" resonance between these surveys. For instance, GAIA will provide accurate distances for nearly all stars in our galaxy brighter than m_v = 16, while TESS and ZTF will provide better than 1% photometric precision for these same sources, and SDSS 5 will provide R~2000 spectra. Stars brighter than about m_v =12 will have exceptional photometry from TESS (~1000 ppm/hr^1/2), multi-epoch spectra and radial velocities from GAIA, and R~20,000 near IR spectra from Sloan 5. Hence, a wealth of complementary data will exist for hundreds of millions of relatively bright (m_v < 17) stars.

LSST will go much deeper than existing time domain astronomy (TDA) surveys and most of the transients found in LSST cannot be follow up spectroscopically. Fortunately, the depth of ZTF, ATLAS and PS-1 is extremely well suited for follow up spectroscopy on a wide range of telescopes: 2-m telescopes (equipped with ultra-low resolution spectrographs aimed primarily at classification), 4-m telescopes (for spectral sequences) and 8-m telescopes (for nebular studies). Spare fibers from DESI and SDSS V, given that the fibers can be allocated at short notice, allow for creative synergism between the on-going time domain photometric surveys and highly multiplexed spectroscopic facilities. In that sense the on-going TDA surveys will serve as excellent stepping stones to LSST.

We advocate that NOAO prepare for the LSST era by using these ongoing/near future surveys to calibrate its methods for delivering data products, alerts, and follow-up observations. NOAO is currently developing the LSST Community Science Center (LCSC) to provide infrastructure for LSST science. We recommend the LCSC be built to take advantage of the data synergies described above to produce exceptional short-term science, and to prepare for long-term LSST operations.

In order to maximize data mining productivity, the NOAO Data Lab should be designed to allow for cross correlation between these multiple datasets. For instance, for users investigating galactic variables, it will be imperative to use Gaia distances to compute source magnitudes and attempt source classification. These efforts will be bolstered with the ability to cross-reference

with SDSS data. Most importantly for LSST, the Data Lab must use provide photometric data analysis and visualization tools. Prototype tools that incorporate ZTF public survey data are a natural step towards managing the full LSST dataset. The ZTF data can also be used to calibrate the ANTARES alert and transient classification system.

As part of this process, NOAO can begin to use its observational resources to follow-up interesting objects uncovered by ongoing surveys. This will involve developing strategies to prioritize follow-up observations based on above datasets, and using currently-available instrumentation on NOAO telescopes such as Gemini, Blanco, and SOAR. NOAO should also begin to develop/facilitate partnerships that will allow for more extensive follow-up observations. We recommend NOAO (by itself or working with partnerships) optimize these follow-up efforts by designing alert/prioritization schemes that incorporate currently available data products such as Gaia/ZTF/SDSS data. These schemes may need to be recalibrated when LSST data becomes available, but the initial calibration based on current data sets will be essential, because the monumental follow-up problem cannot be tackled in one step.

While the scientific output of LSST will be revolutionary, much preparation must still be done to take advantage of its capabilities. LSST science operations are still 5 years away, and the NOAO should use this time to prepare for LSST science by incorporating data from current and ongoing missions (including Gaia, TESS, SDSS, and ZTF), to calibrate data analysis tools and follow-up efforts. These efforts will be rewarded in the short-term by exciting science results, and in the long-run by the accruement of experience and preparation needed to manage the LSST dataset.

Finally, the strong photometric resonance between time domain surveys such as ZTF and SDSS V opens up the possibility of a coordinated program which takes advantage of the high cadence of ZTF and the dynamic fiber allocation of SDSS V (and DESI). This partnership could open new vistas of inquiry even into the LSST era.