AS4 Letter of Intent:
The SoELocal Survey: Spectra of Everything within 100 pc

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Massive and homogeneous spectrosocopic surveys, and foremost the four incarnations of SDSS, have literally brought the Universe into view, particularly the extragalactic and high-redshift Universe. Ironically, one of the last and still-unexplored frontiers is right at our doorstep: our local stellar environment within 100 pc.

We propose an AS4 project—SoELocal—to obtain optical spectra of all of the one-million or so stars within a distance of 100 pc (this number is currently uncertain by a factor of 2, but will be put to rest by *Gaia*, by 2020). *Gaia* will have identified all of the stars to $G \sim 20$ mag within 100 pc, via parallaxes accurate to 5% and better (especially if, as seems likely, the mission is extended by several years). Since the faintest M stars have absolute magnitude ~ 15 mag, and extinction is negligible at these distances, this will be a truly complete census of all the stars in our neighborhood, enabling volume-limited studies using large numbers. (White dwarfs, which have a similar faint limit in absolute magnitude, are covered in a separate LOI.) To cover the full sky, we propose parallel observations, at the APO 2.5m with the BOSS spectrograph, and at the LCO 2.5m with a BOSS clone. With a mean sky target density of ~ 25 deg^{-2}, fields at high Galactic latitude will use of order 100 fibers per plate/pointing, and near the plane up to a few hundred fibers. Assuming a 1-hr total exposure per field, covering the full 100-pc volume will require 300 nights (10-hr nights) at each telescope. The project would thus use about 1/4 of the total time of a 5-year SDSS-V program. The standard SDSS splitting of every epoch into several consecutive exposures (for cosmic-ray removal) will reveal, by means of RV variations, the close (periods of one-to-a-few hours) binaries, with either M-star or WD companions, and possibly neutron-star or black-hole companions. Robotic fiber positioners are not essential but will naturally make the survey much more efficient.

Although *Gaia* will select this sample of local stars and will give their rough stellar type, the very-low-resolution ($R = 100$) *Gaia* spectra will be insufficient for anything beyond this, and only few of the stars in the sample will be bright enough ($G < 16$) for the high-resolution *Gaia* spectrograph covering the Ca-triplet region. The ground-based spectra we propose are therefore essential in order to make this a truly useful and complete spectral legacy collection of all of the local stars. Similarly, the *Gaia* data will give only five of the six phase-space coordinates of every star (sky position, distance, proper motion), and a ground-based spectrum is required for the radial velocity, and thus for a full kinematic image of our stellar neighborhood.

About 3/4 of the stars in SoELocal will be M dwarfs, 1/8 K stars, and of order 5% G stars. Rarer stars will have progressively smaller fractions, but often still large numbers, simply because of the large size of the sample. The 100 pc sample represents about 10^{-5} of all stars in the Galaxy, so all populations with more than 10^5 exemplars in the Galaxy will be represented. Some main science drivers of SoELocal are outlined here, but we are confident that such a legacy sample will have many additional, and even unforeseen, applications.

- BOSS-like spectra will give individual stellar element abundances (for up to ten elements at $g = 18$ mag) and abundance patterns, yielding the most comprehensive

census of abundance patterns in the solar neighborhood.

- The full kinematics will permit cleanly separating the sample into disk and halo stars and to study the kinematic structure of the local disk.
- With such a complete and homogeneous spectral dataset, we will measure the detailed distributions of stellar mass, metallicity, and abundance patterns (e.g. α-element enhancement). Using forward modeling, we can then derive the definitive IMFs of disk stars for masses $M < 1M_{\odot}$, separated by formation epoch and by metallicity.
- The observed stellar distributions in phase space and in abundance patterns will serve as anchors for modeling the global dynamics of the disk.
- We will probe the activity fractions of low-mass stars using Hα and Ca H&K emission. In AFGK stars, the emission can serve as a stellar age estimator. These spectroscopic activity indicators will be complemented by hundreds of photometry epochs from *Gaia*, PTF, ATLAS, etc., and eventually LSST.
- The close binaries not visually resolved by *Gaia* will be identified via their composite spectra, by their UV (Galex) or IR (WISE, Euclid, WFIRST) excesses, or by their RV changes, adding up to a highly complete census of binarity and multiplicity in this local volume, and its characterization (separation and mass-ratio distributions).
- The spectra will identify rare objects in relatively large numbers, and will establish their statistics. Some examples are carbon stars—likely binary products, and metal-poor M sub-dwarfs, thought to be a halo/thick-disk population, and of which only a few tens are known. SoE will find several thousand sub-dwarfs and possibly hundreds of ultra-metal-poor stars, the oldest stars in the Galaxy.
- The majority of ongoing and upcoming searches for planetary and brown-dwarf companions (WASP, MASCARA, CHEOPS, TESS, PLATO) target stars within a similar nearby volume. The full spectral database can both guide such searches (e.g. enable choosing stars in particular metallicity ranges) and provide a complete and statistically solid base for the subsequent analysis of the demography of exoplanets and brown-dwarf companions.

In summary, an AS4 SoELocal survey and its legacy dataset will create the definitive benchmark for the full local stellar population, and will illuminate this closest, yet still-dark, corner of our surroundings.