New data help astronomers explore the hidden Milky Way

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SDSS-III scientists, left to right: Garrett Ebelke (Apache Point Observatory), Gail Zasowski (former U.Va. graduate student, now at Ohio State University), Steven Majewski (U.Va.) and John Wilson (U.Va.). Majewski is actually standing across the room and appears as a reflection in a mirror that was being installed in the spectrograph. Credit: Dan Long

(Phys.org) —Today, astronomers with the Sloan Digital Sky Survey III, or SDSS-III – including University of Virginia astronomers – released a new online public data set featuring 60,000 stars that are helping to tell the story of how our Milky Way galaxy formed, the subject of scientific speculation and debate for hundreds of years.

The highlight of today's "Data Release 10" is a new set of high-resolution stellar spectra – measurements of the amount of light given off by a star at each wavelength – using infrared light, invisible to human eyes but able to penetrate the veil of dust that obscures the center of the galaxy.

"This is the most comprehensive collection of infrared stellar spectra ever made," said U.Va. astronomy professor Steven Majewski, the lead scientist for the Apache Point Observatory Galactic Evolution Experiment, or APOGEE, an effort to produce a comprehensive census of our Milky Way galaxy created and led by U.Va. astronomers. "These 60,000 stars are selected from all the different parts of our galaxy, from the nearly empty outskirts to the dust-enshrouded center. Our spectra are allowing us to peel back the curtain on the hidden Milky Way."

The new spectra are the first data released by APOGEE. The project uses a high-resolution, infrared-sensitive spectrograph largely designed and built at U.Va. It is one of four major experiments of the $45 million Sloan Digital Sky Survey III.

"The spectrum of a star provides key information about not only its temperature and size, but its chemical composition," said Michael Skrutskie, chair of astronomy in the College of Arts & Sciences, who leads the U.Va. instrument lab that constructed the one-of-a-kind, advanced-technology APOGEE spectrograph. "Knowing the detailed chemical composition of a star unlocks powerful information about its origins and how it will evolve – like knowing a person's DNA instead of just their height and weight."

APOGEE's three-dimensional map will provide key information for resolving central questions about the formation and evolution of our galaxy over billions of years. The Milky Way currently has three main parts: a high-density oblong bulge in the center, the flat disk where we live and a low-density spherical component called the "halo" extending out hundreds of thousands of light years.

"Stars in these different regions have different ages and compositions, which means they formed at different times and under different conditions throughout the history of our galaxy," says Gail Zasowski, an National Science Foundation Postdoctoral Fellow at Ohio State University and a recent Ph.D. graduate from U.Va., who led the critical effort to maximize APOGEE's scientific potential by selecting the best possible sample of stars.

If you look up at the night sky from a dark site, far away from the overwhelming glow of city lights, the Milky Way galaxy appears as a luminous band across the sky, overlaid with dark curtains. This band is the disk and bulge of our galaxy, and the curtains are the dust that blocks visible light from more distant parts of the Milky Way.

Because of this dust, previous studies of stars in the Milky Way have been limited in their ability to consistently measure stars toward the center of our galaxy. APOGEE's solution is to look in infrared light, which can pass through the dust. This ability to explore previously hidden regions of the galaxy allows APOGEE to conduct the first comprehensive study of the Milky Way, from center to halo.

Observing tens of thousands of stars is a time-consuming task. To accomplish its goal of observing 100,000 stars in just three years, the APOGEE instrument observes up to 300 different stars at a time using fiber-optic cables plugged into a large aluminum plate with holes drilled to line up with each star. Light passes through each fiber into the

APOGEE spectrograph, where a prism-like grating distributes the light by wavelength.

"The grating is the first and largest of its kind deployed in an astronomy instrument," said John Wilson, a senior scientist in astronomy at U.Va. who led APOGEE's instrument design team. "That technology is critical to APOGEE's success."

APOGEE's spectra of stars will help unlock the history of our galaxy, and the key is learning the compositions and motions of stars in each region. Because elements heavier than hydrogen and helium were produced in stars and spread through the galaxy by stellar explosions and stellar winds, astronomers know that stars with more of these heavy elements must have formed more recently, after previous generations of stars had time to create those heavy elements.

"Our goal is to take a comprehensive census of how stars with different levels of chemical enrichment, and therefore age, are distributed throughout the Milky Way, and combine this with information on how those stars are moving – another property derived by APOGEE – to formulate a detailed history of the formation of the galaxy," said Fred Hearty, a U.Va. staff scientist in astronomy and the project manager for APOGEE. "The level of chemical detail provided by APOGEE may even allow us to track stars to specific birth sites, and identify stars that were formed in other star systems that were subsequently cannibalized by the Milky Way."

APOGEE data also provide a rich context for investigating a wide range of questions about the stars themselves. Because APOGEE observes each target star several times, it can identify changes in each star's spectrum over time. This feature has enabled the APOGEE team to discover unusual types of rapidly variable stars, to pinpoint how many stars are actually binary stars with unseen companions, and even to detect the subtle stellar motions caused by orbiting exoplanets.

Data Release 10 also publishes another 685,000 spectra from the SDSS-III Baryon Oscillation Spectroscopic Survey, or BOSS. These new spectra come from galaxies and quasars as seen when our universe was much younger, just as the mysterious force of "dark energy" was beginning to influence the universe's expansion. The new BOSS spectra, and the additional spectra that the SDSS-III will continue to obtain in the final years of the survey, will help scientists in their quest to understand what dark energy might be.

SDSS-III is a six-year survey of nearby stars, the Milky Way galaxy, and the distant cosmos. The Sloan Foundation 2.5-meter telescope at Apache Point Observatory in New Mexico conducts observations every night that feed either the BOSS optical or APOGEE infrared spectrographs. U.Va. is one of several universities that runs the observatory, which includes not only the Sloan facility but other telescopes as well.

"We've been putting out data releases since 2001, and we're not slowing down yet," said SDSS-III spokesperson Michael Wood-Vasey of the University of Pittsburgh. "Public access to data has always been a key goal of our project, and we're proud to continue that tradition today with this new release rich with information about our own galaxy."

All of these data are available to researchers and the public here.

Provided by University of Virginia

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