FAST BREAKING PAPERS - 2009

April 2009

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Mario Juric talks with *ScienceWatch.com* and answers a few questions about this month's Fast Breaking Paper in the field of Space Science. The author has also sent along images of his work.

Article Title: The milky way tomography with SDSS. I. Stellar number density distribution
Authors: Juric, M, et al.
Journal: ASTROPHYS J
Volume: 673
Issue: 2
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(addresses have been truncated)

SW: Why do you think your paper is highly cited?

The relatively large number of citations is likely a combination of recent resurgence of interest in studies of the Milky Way, and the number of discoveries and measurements described in this paper.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

This paper is the first in a series that describes our findings about the structure of our galaxy, the Milky Way, as seen by the Sloan Digital Sky Survey (SDSS).

It describes the measurements of Galactic structural parameters (in essence, how the stars are distributed in our Galaxy) from a dataset 400 times larger than comparable prior ones, the discovery and characterization of "Virgo Overdensity" (a large overdensity of stars caused by a merger of a satellite galaxy with our own), and the general methods that may be used to repeat this kind of research with future large-scale surveys.

SW: Would you summarize the significance of your paper in layman's terms?

In layman's terms, we measured the positions and distances to over 40 million stars, 400 times more than prior comparable surveys, and (within the volume observed) produced the most accurate map of the Galaxy to date. This enabled us to measure the size and height of the disk of our Galaxy to unprecedented accuracy, as well as the shape of the tenuous envelope of stars surrounding the Galactic disk (the "Galactic halo").

In the process, we discovered a huge overdensity of stars, extending over an area of the sky equivalent to 5,000 full Moons, in the direction of the constellation Virgo. This "Virgo overdensity" is likely a remnant of a merger of a smaller galaxy with our own.

The big picture of our results is that by providing an accurate picture of the Milky Way, we have created a test, a benchmark, against which the theories and simulations of Milky Way formation will be compared in the decades to come.

SW: How did you become involved in this research, and were there any problems along the way?

This research began as a joint project with Dr. Zeljko Ivezic, then at Princeton University and now a professor in the Department of Astronomy at the University of Washington in Seattle and project scientist of the Large Synoptic Survey Telescope. However, it quickly evolved into a comprehensive study of the Galaxy with SDSS data.

There were many problems along the way, ranging from technical (e.g., our datasets included hundreds of millions of observations and were typically on order of 50GB in size), to astrophysical (e.g., assessing whether unidentified multiple stars—those are too close to each other to be resolved in our telescopes—can influence our conclusions).

SW: Where do you see your research leading in the future?

My present focus is directed towards the understanding of the Milky Way by using large sky surveys. I believe these surveys can lead us to a complete picture of structure, formation, and evolution of the Milky Way before the next decade is out.

The next such survey is PanSTARRS—Panoramic Survey Telescope & Rapid Response System. It will be capable of extending the reach of our SDSS study by factors of 10-100. This is what I plan to work on following my move as a NASA Hubble Fellow to Harvard University later this year.

Figure 1: +details

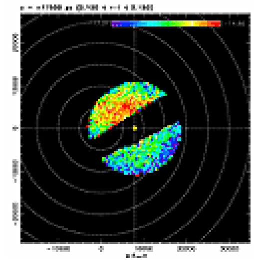


Figure 2:

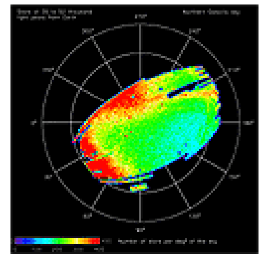
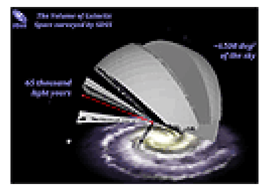


Figure 3:



SW: Do you foresee any social or political implications for your research?

There will be little impact to the general public. However, I hope it will influence the way in which the astrophysics community thinks about surveys, as well as the way we teach and train our students today for the challenges of the future.

An important aspect of this research is that it was enabled and done entirely using an existing dataset produced by a large sky survey (the SDSS) that was originally built for an entirely different purpose (observations of far-away galaxies). While such reuse of archived data has certainly happened in the past, because of the proliferation of information technology and survey datasets I expect it will become common to the point of dominance in the not-so-distant future.

The upcoming prevalence of such datasets will move the focus in astronomy from data collection to data mining. This will, in turn, require a shift in astronomers' thinking to a frame of mind quite opposite from the one we are used to. Instead of "given the topic, what data would be best to understand it?" one will instead need to ask "given the data, which topic can be advanced the furthest?"

Successful data-driven astronomers will have to know the datasets at their disposal, have broad interests and understanding of various areas of astrophysics, and an intimate knowledge of computing and data mining techniques. These skills and ways of thinking are something that we must work to instill in our students in order to prepare them for the survey-driven astronomy of tomorrow.

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KEYWORDS: DIGITAL SKY SURVEY; METAL-POOR STARS; PHOTOMETRIC PARALLAX ESTIMATION; TRIANGULUM-ANDROMEDA REGION; SYNOPTIC SURVEY TELESCOPE; SURVEY COMMISSIONING DATA; GALACTIC LATITUDE FIELDS; HORIZONTAL-BRANCH STARS; DARK-MATTER UNIVERSE; PROPER-MOTION STARS.

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2009 : April 2009 - Fast Breaking Papers : Mario Juric - Figures & Descriptions

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Figures and descriptions:

Figure 1:

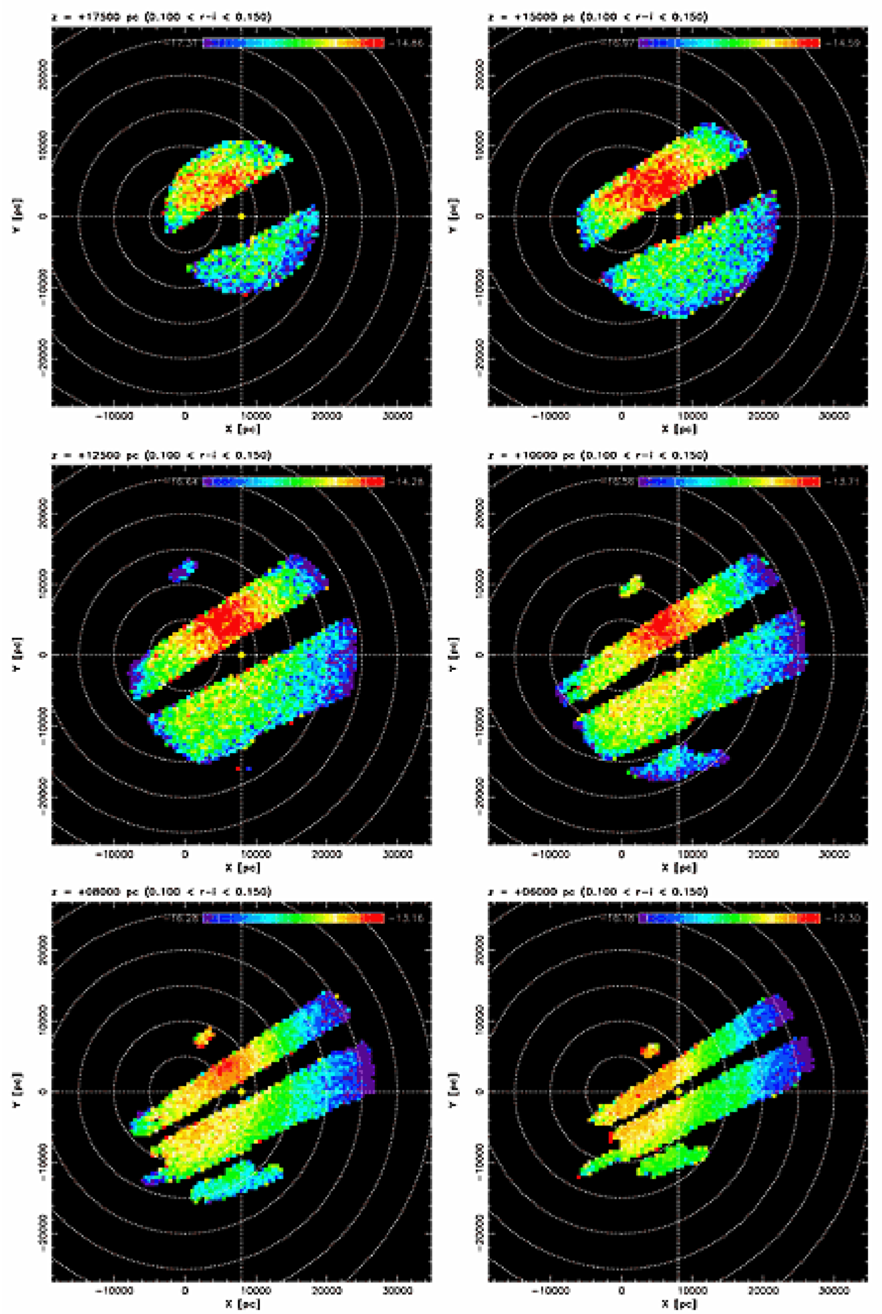

Figure 1:
False-color stellar number density in slices parallel to the Galactic plane (red -- areas many of stars, blue -- areas with few stars). The distance from the plane varies from 17.5 kpc (top left) to 6 kpc (bottom right). The circles visualize the expected axial symmetry of the Galaxy, and the origin marks the location of the Galactic center. The Sun is at X=8000, Y=0 parsecs (1 parsec equals 3.26 light years). Note the strong asymmetry with respect to the Y=0 line, caused by the red "blob" at X~6000,Y~4000. This is the newly discovered "Virgo Overdensity," likely a remnant of a merger of a smaller satellite galaxy with the Milky Way.

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Figure 2:

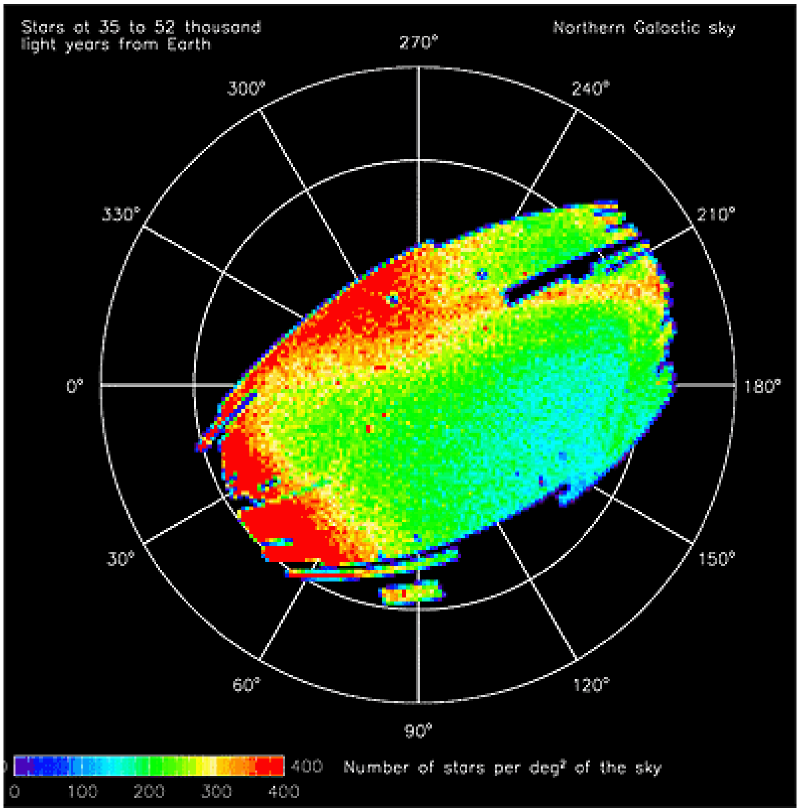

Figure 2:
Another way of visualizing the Virgo Overdensity: A false-color depiction of stellar number density in a shell 35-52 thousand light years from Earth. Red are the areas with many stars, while blue areas have few stars. Noticable in the picture are the Virgo Overdensity as a red blob in the upper left quadrant near the edge of the surveyed sky, and another stream of stars in the first quadrant that overlaps the Virgo Overdensity, the Sagittarius Stream. Both of these structures are thought to be remnants of mergers of smaller satellite galaxies with the Milky Way.

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Figure 3:

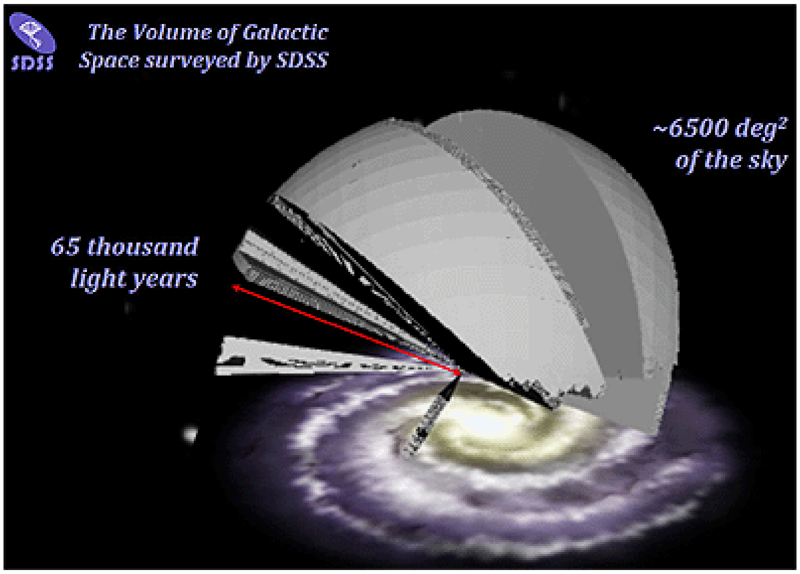

Figure 3:
The volume of space in and around the Milky Way that has been surveyed by the SDSS and studied in this paper (artistic depiction of the Milky Way disk courtesy of NASA).

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