Case 88

Sloan Digital Sky Survey

Alfred P. Sloan Foundation, 1995

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Background. Until the mid-1990s, the last comprehensive study of a large portion of the cosmos was one undertaken in the 1950s by researchers at the Mount Palomar Observatory.\(^{1254}\) This study remained state-of-the-art for forty years, until the Alfred P. Sloan Foundation moved to fund a new astronomical survey unprecedented in its breadth and depth. This “intergalactic census” would be conducted by the nonprofit Astrophysical Research Consortium, a partnership of research universities and laboratories, including the University of Chicago, Johns Hopkins, Princeton, and teams of researchers from Japan, Germany, and elsewhere.\(^{1255}\) Each would provide manpower and funds, as would the federal government. But the project was initiated with Sloan Foundation funding, and, as evidenced by its name, the Foundation would remain its leading supporter. Once planning and design had been completed, the construction phase of the Sloan Digital Sky Survey (SDSS) got underway in 1995. At the time, scientists had accurate measurements of distance “for only a few tens of thousands of galaxies.”\(^{1256}\) With powerful new equipment and advanced research and analytic techniques, SDSS scientists would soon surpass tremendously this and other measures of progress in the field of astronomy.

Strategy. To that end, state-of-the-art observation equipment—including a 2.5-meter telescope and twin spectrographs each measuring 8.5 feet in length—was built and installed at the Apache Point Observatory in New Mexico. In February 1998, the massive SDSS telescope first cast its eye skyward, and, by early 1999, data collection at Apache Point—which is managed by the University of New Mexico—was proceeding at full speed. With a view of one quarter of the night sky, the Sky Survey telescope contains one of the most technologically advanced cameras ever built.\(^{1257}\)

Photons hit the telescope and are collected by light sensors known as charge coupled devices. Images are then recorded onto magnetic tape, which is shipped by express courier to the Fermi National Accelerator Laboratory (Fermilab), the most advanced high energy physics laboratory in the world. Information is sent through Fermilab’s Feynman Computing Center through various data pipelines (such as the spectrographic, astrometric, and monitor pipelines), each of which was developed by one of the collaborating research institutions to process huge data sets into information about various celestial objects, such as stars, nebula, and quasars. This information is then collated in an Operations Database, run by Fermilab and the U.S. Naval Observatory. Eventually, data sets are passed on to scientists at Johns Hopkins, who make it available (via a digital search engine) to researchers working with SDSS.\(^{1258}\) Beginning in 2003, SDSS also releases periodically huge sets of its data to the general public. The total volume of information to be collected is estimated to fill some 20- to 40-trillion bytes of hard disk space.\(^{1259}\)

In this way, SDSS is constructing a digital map of a full quarter of the night sky. In effect, it is constructing a three-dimensional field guide to the visible universe, and one with a volume 100 times greater than any picture of space humans had previously constructed. All told, SDSS will obtain detailed data—such as position and absolute brightness—on over 100 million celestial objects. Unlike most astronomical observations, which are limited to one spectrum, the SDSS uses color filters to view these objects in five different colors, which reveals a broader range of characteristics than are visible in any one wavelength.\(^{1260}\)

Outcomes. SDSS is “the most comprehensive mapping survey of the cosmos ever undertaken.”\(^{1261}\) It has already produced 15 terabytes of data—nearly the same amount of information stored by the Library of Congress.\(^{1262}\) Two massive data releases have given to the public a detailed look at tens of
millions of astronomical objects, including redshifts of more than half a million.” In order to manage its findings, SDSS has also pioneered an early “universal ‘sky partitioning’ system,” which, according to Dr. Alex Szalay, an astrophysicist at Johns Hopkins, “will become increasingly necessary as more massive sky surveys are produced.” To date, the Sloan Digital Sky Survey has cost approximately $80 million, of which the Sloan Foundation has provided one quarter. Additional funding has come from the National Science Foundation, NASA, and the individual Consortium members. The Survey was planned to operate for five years (from 1999 to 2004). However, in 2004, the Board of Trustees of the Sloan Foundation approved an additional $5.4 million to fund partially a $15 million extension of the program to enable it to meet its original aim of encompassing “the entire northern galactic sector...”

Impact. The Sloan Survey is enabling breakthrough research to be undertaken. In 1999, for instance, SDSS astronomers “discovered that typical galaxies may be twice as large and contain twice as much mass as suggested by previous measurements.” SDSS data already “contain more spectra than [had previously] been published in the history of science.” Last year, SDSS data were used “to calculate an important confirmation of the discovery of dark energy, the negative gravitational force that accelerates matter repulsively.” These and other advances have driven the formulation of new theories on the nature and origins of galaxies and the universe itself. Yet it may be that SDSS has yet to yield its greatest impacts. Dr. Anneilia Sargent, a Cal Tech astronomer who is president of the American Astronomical Society, has predicted that the Survey is going “to turn a great many astronomical theories on their heads and confirm others.” And in fact SDSS is more than a leap forward in human understanding of the cosmos; for in creating a framework “sky partitioning system,” SDSS has laid a foundation for the next generation of astronomical research.

Notes

1254. In fact, this study was also made possible by a charitable foundation. See case study on the Rockefeller Foundation’s underwriting of the construction of Mt. Palomar’s 200-inch Hale Telescope.
1256. Ibid.
1259. “A Million Galaxies to be Tracked,” *Johns Hopkins Gazette*.
1260. Ibid.
1263. Ibid.
1264. “A Million Galaxies to be Tracked,” *Johns Hopkins Gazette*.
1267. “A Million Galaxies to be Tracked,” *Johns Hopkins Gazette*.