RESEARCH FACILITIES AND PROGRAMS

Spectroscopy at NYU

Research on atomic hyperfine structure and isotope shifts has begun at the Bronx campus of New York University in a new laboratory containing a high-resolution optical spectrograph of 10-meter focal length. Henry H. Stroke, associate professor of physics, built the laboratory for a systematic study of heavy radioactive isotopes. The National Science Foundation gave $178 100 for construction and four years of research.

To gain the necessary resolution, the instrument has a 25.4-cm plane-blazed diffraction grating in a Czerny-Turner mount. The whole thing is housed in a light-tight room-within-a-room where temperature is controlled to within 0.1°F. It rests on two vibration-insulated piers that go down to bedrock and hold it stable to a maximum movement of 0.1 micron.

For experiments, discharge lamps are prepared from samples of radioactive material produced in a cyclotron or reactor. Some of the samples, with half-lives of a few hours, have been made at Harvard and brought to NYU by automobile to be refined, distilled and made into lamps, all before they decayed.

Stroke is beginning his work with high-resolution studies of visible and near-ultraviolet spectra of atoms with radioactive nuclei. He is investigating nuclear-charge distribution by isotope-shift measurements. At the same time he is attempting to correlate deformations (from vibrations) with the orbits into which neutrons go.

The laboratory also has a 10-kg magnet (and some smaller magnets) for optical level-crossing studies and Helmholtz coils for research on the atomic-radiation process itself. Meteorolgists and oceanographers plan to use the spectrograph for geophysical problems (including high-resolution studies of sunlight that they will "pipe" into the laboratory), and other physicists want to do solid-state and astrophysical research.

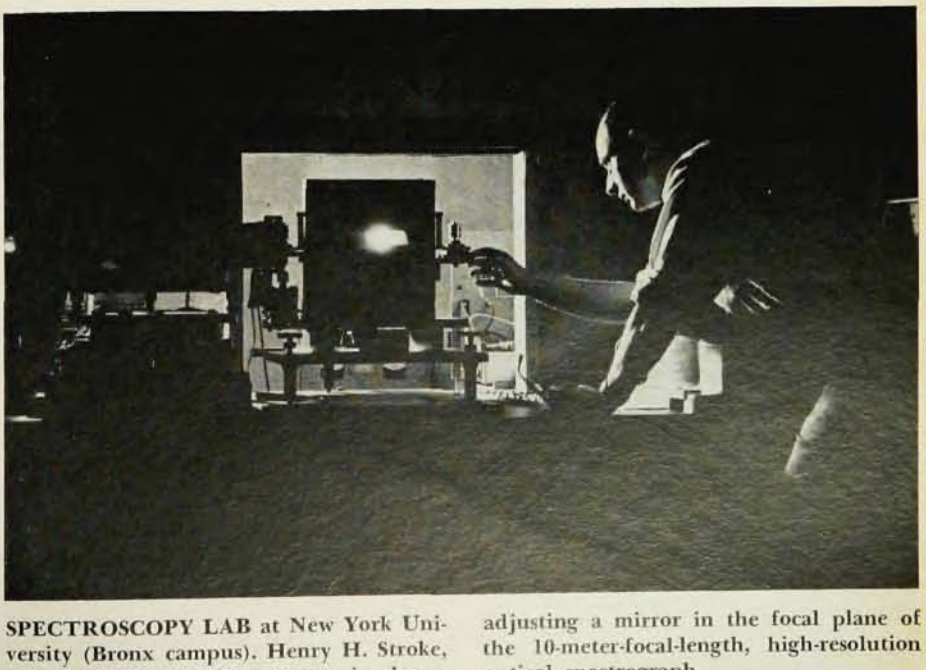
Supernovas may fluoresce

Philip Morrison and Leo Sartori have presented a theory involving fluorescence of interstellar gas clouds to explain the observed spectra of Type I supernovas. According to their argument [Phys. Rev. Letters, **16**, 414 (1966)], most of the supernova light comes from a gas cloud surrounding the exploding center, which is excited by ultraviolet radiation from the explosion.

The objects in question show a sudden, sharp flash; their photographic light curves (log of luminosity from 380 to 520 millimicrons) rise in a few days to an average maximum greater than 10^9 times solar luminosity. Afterward they dim rapidly for 20 or 30 days, then go into an almost exponential decline with a half-life of 40 to 80 days. The decline can continue in this fashion for nearly two years. During the early period the color reddens rapidly, but after about 40 days it becomes bluish and after about 100 days stays approximately constant.

The spectrum consists mainly of broad bands about 10 to 20 millimicrons wide, the brightest of which peaks near 460 millimicrons and contains nearly half the total intensity in the photographic region. This peak and three others in the blue (490, 480, and 430 millimicrons) show a gradual redshift leading to an overall displacement of about 10 millimicrons in each case. Red features of the spectra behave erratically.

The authors assume that the bulk of the direct energy release is a sudden burst lasting at most a few days. At first the radiation is concentrated in the ultraviolet or beyond, but it shifts to lower frequencies as time goes on. Thus the visible power increases even while the total emission goes down. After maximum the direct emission decreases so rapidly that it soon becomes negligible. Thus the light observed after ten or 20 days is fluorescence—that is, visible light emitted by interstellar gas that has been excited by the original ultraviolet emission. As time goes on the fluorescence emanates from regions farther and farther from the center so that the observed near-exponential decline in brightness with time represents the essentially ex-



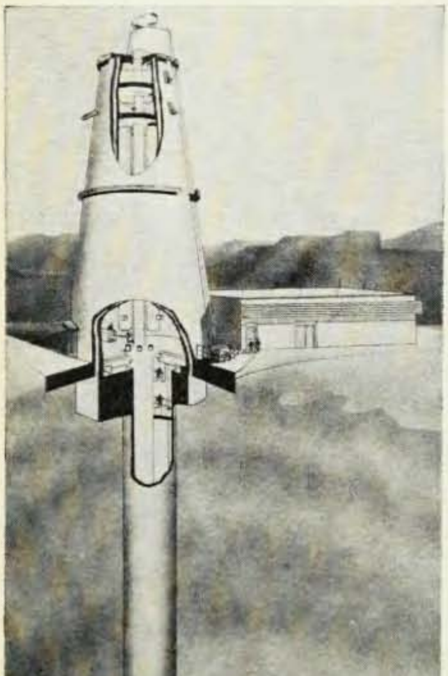
SPECTROSCOPY LAB at New York University (Bronx campus). Henry H. Stroke, who designed the instrument, is shown adjusting a mirror in the focal plane of the 10-meter-focal-length, high-resolution optical spectrograph.

ponential attenuation of the original ultraviolet as it spreads out in space. The most important fluorescence emitter is the ion He II, whose lines account for the majority of spectral features.

At the same time that it creates the fluorescence, the original photon outburst also accelerates the gas in its path away from the center of the explosion and the motion imparted to the fluorescing atoms accounts for the line broadening and shifts. In the beginning, for kinematical reasons, most of the observed fluorescence comes from regions on the near side of the explosion, and thus arises the blue-shifted appearance of the spectrum. Later on, radiation from the far side will dominate, and the redshift will take over.

Solar telescope

A high-resolution solar telescope will soon be constructed to study high-energy proton showers associated with sunspot activity. Air Force Cambridge Research Laboratories will build the telescope at its Sacramento Peak Observatory in Sunspot, New Mexico, at a cost of $3.2 million. It will feature a rotatable 98-meter interior tube containing the optical system and instrumentation under vacuum. The resulting elimination of air turbulence and dust will improve resolution. Researchers will attempt to predict periods of absence of proton showers, which are a potential hazard to men in space. Solar activities are also known to have a profound effect on the earth's weather and on communications and detection systems.



NEW SOLAR TELESCOPE at Sacramento Peak (artist's impression). Optical equipment will be contained in vacuum in the inside tube, which will be 98 meters long.

Slow relativistic electrons

The scattering of slow electrons by atoms is generally calculated by neglecting relativistic effects. However for heavy atoms, very slow electrons and certain simplifying assumptions, H. N. Browne and Ernst Bauer have recently shown that relativistic and nonrelativistic cross sections are quite different.

Browne and Bauer assumed that an atomic electron moves in a spherically symmetric potential produced by the nucleus and all the other electrons. This static central field approximation neglects both exchange and polarization effects resulting from the repulsive force between particles (here electrons) with identical spin and charge.

Comparing the relativistic and nonrelativistic equations for each partial wave (in the partial wave expansion) Browne and Bauer found that the relativistic contributions to the first two terms of the equations decrease with decreasing energy, as one would expect. But the other relativistic terms in the equation tend to dominate with increasing atomic number and decreasing electron energy.

To see just how important these terms are, the authors calculated total scattering cross sections of helium, krypton, cesium and mercury at electron energies of 2, 20 and 200 eV. Relativistic effects increased with atomic number and decreased with electron energy. At 200 eV the effects were a few percent but at 2 eV the relativistic cross sections were sometimes an order of magnitude different from nonrelativistic cross sections (either larger or smaller).

As one theorist explains, relativity is important at low energies because a small change in the wave function produces destructive interference, just as a small change in the thickness of a thin film produces destructive interference.

Although low-energy relativistic effects are pronounced in these scattering calculations, so is the low-energy variation of cross section with the potential used. The authors calculated mercury cross sections for example, assuming four different types of potentials: Hartree-Fock-Slater, relativistic Hartree, Thomas-Fermi-Dirac, and Thomas-Fermi. At 2 eV some cross sections differed by orders of magnitude. Browne and Bauer note that these results clearly demonstrate the need for better wave functions.

The authors conclude on a cautionary note to theorists: when calculating slow-electron scattering by heavy atoms, be sure to worry about relativity while you are worrying about exchange and polarization.

Browne and Bauer are at Michelson Laboratory, China Lake, California. Their work is reported in *Physical Review Letters*, 21 March 1966.

Neutron shape

Knowledge of neutron structure is in a little better shape due to recent measurements of electromagnetic form factors. Experiments with the Cornell electron synchrotron indicate that if the neutron has any charge density distribution at all it is probably very small.

The tool for neutron microscopy is a scattering reaction; the magnification is roughly proportional to q, the magnitude of the invariant 4-momentum given to the neutron in a reaction (q has units of F^{-1} since it varies inversely as de Broglie wavelength). By scattering electrons from a deuterium target the Cornell group probed the neutron's electromagnetic structure from 5.5 F^{-2} to 14.5 F^{-2} and, within experimental limits, the electric form