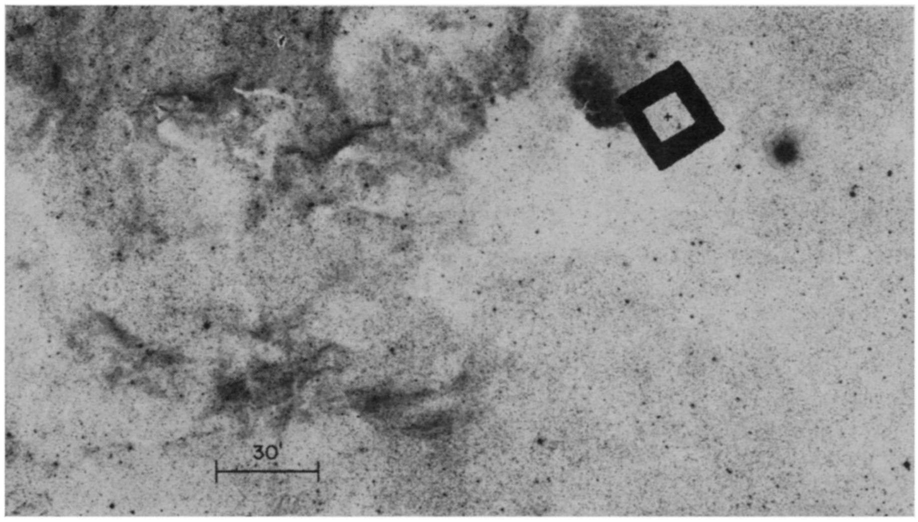


National Geographic-Palomar Sky Survey

Optical object in Cygnus has been identified as an X-ray emitter.

X-RAY ASTRONOMY

A Science in High Gear

Rocket-borne instruments open new radiation region to scientists; results pour in faster than normal communications channels can handle them.

by Ann Ewing

The relatively new field of X-ray astronomy, opened only since rockets were hurled accurately beyond the bulk of earth's atmosphere, is providing important clues to energy sources in stars, galaxies and cosmic space.

The softest X-rays, having an energy of some 100 electron volts, cannot penetrate a sheet of paper. Hard X-rays, of the kind received by a patient examined in a doctor's office, have energies of hundreds of millions of electron volts.

Although hard X-rays penetrate much farther into the atmosphere than do soft ones, that is, to about 75,000 feet, there is so much other radiation at this balloon altitude that it is difficult or impossible to make astronomical observations there.

The reason stars emit X-rays is not known, although the radiation is definitely associated with high temperature plasmas and the interactions of high energy particles, not with radium as are many of the medical X-rays.

Since the discovery of discrete sources of X-ray emission from the sky in 1962—some of them star-like objects—new findings concerning their number and distribution have been reported at a gaspingly fast pace. Astrophysicists have also been straining their theories to explain why X-ray sources generate radiation in this wavelength at all.

The pace has been so fast that many of the discoveries are communicated to interested astronomers by preprints of reports submitted to such publications as the ASTROPHYSICAL JOURNAL, NATURE, SCIENCE, and PHYSICAL REVIEW LETTERS, all of which have relatively short lag times between submission and printing.

Some of the findings have such important implications as to how energy is generated that conservative scientists seriously consider reporting their results in newspapers and other communications media even before they have appeared in a scientific journal or been detailed at a meeting.

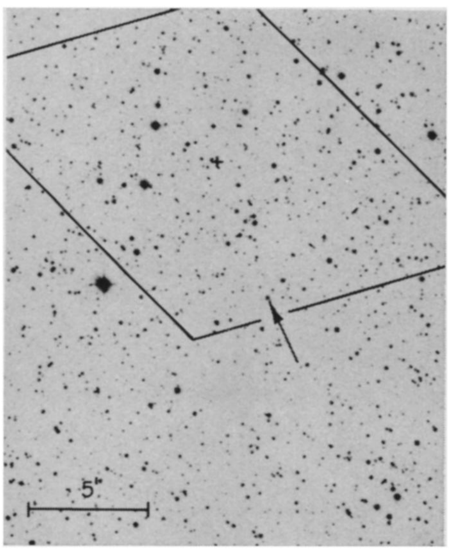
Such a reversal of the usual procedure would not even have been thought of by most scientists a few years ago.

This month alone, scientists will learn of:

• Tentative identification of the first quasar emitting X-ray radiation. Scientists at the Naval Research Laboratory in Washington believe they have detected X-rays emitted by the quasar known as 3C-273-B.

• New clues concerning the density of interstellar matter based on the distribution of X-ray sources around the plane of the Milky Way galaxy. The improved map of distribution is being analyzed by scientists at American Science and Engineering in Cambridge, Mass.

• The third identification of an X-ray source with an optically known object, this one in the constellation of Cygnus. This identification was a joint effort of ASE scientists and astronomers from Mt. Wilson and Palomar Observatories. Details are reported in the June ASTROPHYSICAL JOURNAL. From recent examination of photographic plates taken as early as 1901, this object has been found to have a rapidly fluctuating light output of about one magnitude.



Sky Survey

Detail of region shown at left.

The early experiments in X-ray astronomy were concerned exclusively with the sun, some of whose X-rays are now known to have a major controlling influence on the quality of shortwave radio communications.

Dr. Herbert Friedman of the Naval Research Laboratory, a pioneer in rocket and satellite astronomy, believes that the sun's lower corona consists of thin, magnetically trapped threads of plasma. The tightly-looped magnetic ropes in this solar region are "pinched," resulting in rapid increases of temperature and density, producing X-rays.

From these observations have come the suggestion that the lower solar corona is a web of fine magnetic ropes, tightly looped from sunspot to sunspot, covering the sun's surface like a knit sweater. A single thread may stretch 20,000 to 100,000 kilometers from one sunspot to another.

Dr. Friedman also has found that energetic X-ray emissions from the sun fluctuate rapidly, varying as much as 50 percent in a few seconds.

Even more exciting to astronomers than the observations of solar X-rays was the discovery in 1962 of an X-ray source in the heavens, one of relatively great intensity and of a different type than had been predicted.

The bright X-ray source discovered by Drs. Herbert Gursky, Riccardo Giacconi and Frank Paolinit of American Science and Engineering and Dr. Bruno Rossi of MIT in the constellation of Scorpius radiates X-rays with quite remarkable intensity. Although it is light years rather than light minutes away as the sun is, Scorpio XR-1, has a detected X-ray output rivaling that of the sun.

Soon after Scorpio XR-1 was identified, scientists at the Naval Research Laboratory detected X-rays from the region of the Crab Nebula, the giant supernova that exploded on July 4, 1054.

Since then at least 30 discrete sources of X-rays have been detected. Many of them are believed to be associated with supernova recorded during the past 2,000 years.

With the identification of a third known source of both optical and X-radiation, however, scientists now believe that X-ray sources can be divided into two groups. One is a nebulous region, such as the Crab; the other is star-like, such as those in Scorpius or Cygnus.

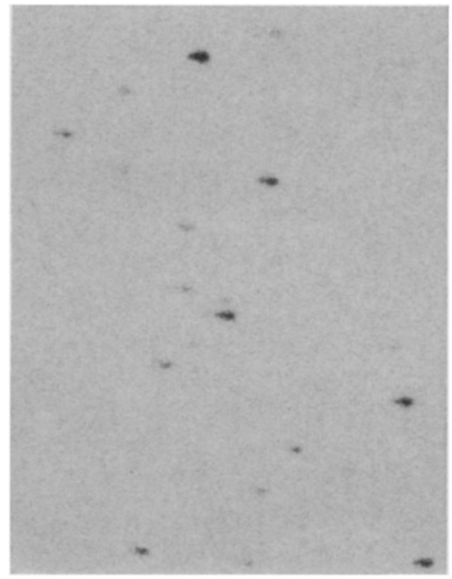
Both of the stellar-type objects have been found to be variable in light output. In order to make a better comparison between the two, astronomers at Mt. Wilson and Palomar Observatories are starting now to take additional photographs of the region containing the source Cygnus XR-2. They hope to "gain more confidence" in the Cygnus identification, according to Dr. Allan R. Sandage of Mt. Wilson and Palomar Observatories and his co-workers.

The ASE group has also found the new clues concerning the density of interstellar matter. Preliminary results from studying their new chart of the distribution of X-ray sources indicate that interstellar matter is denser by a factor of four to six than the one atom per cubic centimeter now generally accepted.

The tentative identification of quasar 3C-273-B as a source of X-rays, the first such known, is being checked by scientists at the Naval Research Laboratory. Their preliminary finding is that the outpouring of X-rays from this quasar is about 100 times its emission in radio waves. The observations were made from an Aerobee rocket launched in early May.

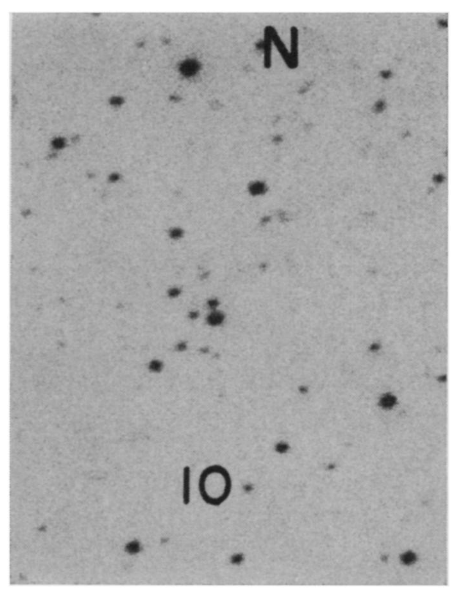
One theory suggested to explain the variability of such objects as Scorpio XR-1 and Cygnus XR-2 is that they are binary systems, one component of which is an old neutron star whose core has cooled to a low temperature.

Dr. I. S. Shklovsky of the Sternberg Institute for Astrophysics in Moscow has suggested that the strong gravitational field of the neutron star acts as a sink in which the gas from its companion star accumulates. The kinetic energy of the in-falling gas, Dr. Shklovsky believes, would be sufficient to provide the X-ray emission of the high temperature plasma that surrounds the neutron star.



Harvard

Plate of Sept. 7, 1948, shows faint dot at X-ray position.



Harvard

17-days later source (to right of 10) had brightened.

Dr. Friedman reports that a "large fraction of old novas are known to be eclipsing binaries." Dr. Shklovsky's neutron star model would permit a wide range of variability in X-ray emission if the binary system were eclipsing, one star blocking out the other as they spin around each other.