INFRARED ASTRONOMY

Exploring the Universe in Infrared

A new technique enables astronomers to obtain in one night data that would otherwise take 150 years.

by Ann Ewing

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Orion Nebula in red light . . .

A new instrument that scientists are now just beginning to use for measuring infrared radiation from planets, particularly Mars and Venus, gives in one night observations that would otherwise take more than 150 years.

Scientists are normally cautious in their appraisals of new instruments and techniques, but they have used such phrases as "extremely impressive," "spectacular" and "brilliant" to describe the early results obtained with the multiplex interferometric Fourier spectrometer—MIFS.

The instrument's recordings of infrared radiation, when analyzed by a digital computer, can show chemicals present in the atmospheres of other planets when the concentration is as low as one part in a billion (see p. 381).

Dr. Lewis D. Kaplan of the Jet Propulsion Laboratory, Pasadena, Calif., says that although he had realized the MIFS was capable of detecting small amounts of the constituents of planetary atmospheres, the instrument was much more sensitive than he had dreamed.

Attached to a 1,000-inch telescope, (SN: 4/15) it could be used to detect extraterrestrial life from earth's surface, since life on any planet, including earth, affects the atmosphere. Such an earth-based exploration would not be "a rival to spacecraft methods, but rather complements them and is a prerequisite for their greatest effectiveness," three scientists closely connected with the development and application of MIFS suggest in the April SCIENCE JOURNAL.

The scientists are Drs. Pierre Connes, director of research at the Center for Scientific Research, Bellevue, France; Peter Fellgett of the University of Reading, Reading, England, and James Ring of the University of Hull, Hull, England.

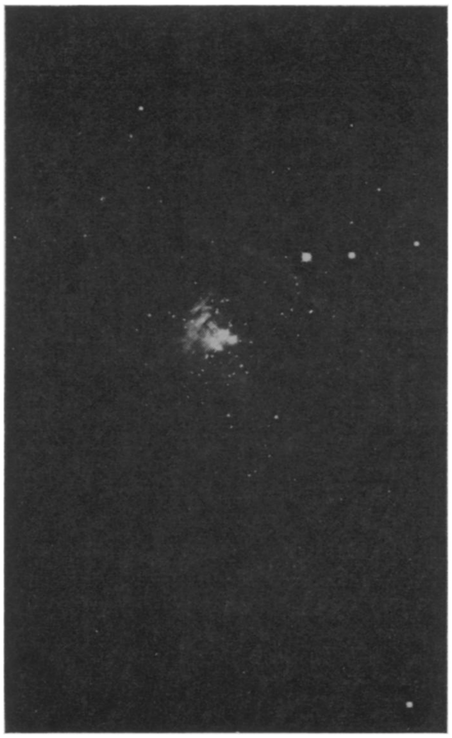
The effects life might have on a planet will be outlined in a forthcoming issue of ICARUS by Drs. Dian R. Hitchcock of Hamilton Standard Division, United Aircraft Company, Windsor Locks, Conn., and James Lovelock of the University of Houston.

Infrared observation of astromonical objects is difficult because the amount of energy radiated in this region is generally small. Moreover, if the observations are made from earth's surface, as most of them are, some of the wavelengths are blocked by the sea of air blanketing the planet.

The gases that are most likely to be indicative of biological processes are those that are clearly not in equilibrium with the environment. Since this implies compounds of high reactivity, the most promising gases for life-detection purposes are likely to be present in very small amounts.

Because of the increase in resolution obtained using MIFS, the chances of detecting such trace gases is greatly increased, making the outlook bright for eventually finding obviously life-related compounds by earth-based observations.

Stars that are very bright in infrared wavelengths, but very faint in ordinary visual and photographic light have recently been discovered using a new type of telescope that jiggles 20 times a second. Two of these objects have been found to have surface temperatures less



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and in infrared radiation.

than 1,200 degrees C. They are, nevertheless, true stars, producing their radiation internally at temperatures of 25 million degrees.

Even more recent is the discovery of what appears to be a new stellar planetary system in the process of forming. Dr. Frank J. Low and graduate student Bruce J. Smith detected the "pre-planetary" system using the infrared telescope designed for long-range observational work by Dr. Harold Johnson, research professor at the University of Arizona's Lunar and Planetary Laboratory.

The spectrum of light from a star or planet contains vital information on how the light is generated and what has happened to it on its travels through space until it is intercepted on earth. This applies not only to visible light, but to infrared and ultraviolet radiation as well as radio waves and, indeed, the entire range of electromagnetic radiation.

In the visible region of the spectrum, a spectograph disperses the radiation under observation, each wavelength being focused onto a separate portion of the photographic plate and thus under observation during the entire exposure.

In the infrared region, however, this cannot be done since photographic plates are not sensitive to such relatively long wavelengths.

A conventional infrared spectrometer, therefore, selects elements of the spectrum one at a time by means of an exit slit, focusing the elements successively on a detector, with consequent loss in sensitivity because any one wavelength is observed for such a short time.

Dr. Fellgett found a way to overcome this disadvantage, using a method known in communications engineering as "multiplexing."

This method, as used in trunk telephone circuits for example, takes a set of separate signals and marks each one by modulating it with a recognizable pattern. The signals are then added together and sent down a single telephone channel.

The modulation patterns enable the different signals to be separated at the receiving end.

A multiplex spectrometer can be made with a chopping disk that imprints a recognizable modulation pattern on each spectral element. All the wavelengths coming through the entrance slit can then be allowed to reach the detector at the same time.

A further refinement is the interferometric multiplex spectrometer, since it allows the light to enter through a large hole instead of a narrow slit. The light beam is split by reflecting mirrors into two beams that can be individually controlled and then combined in such a way that they interfere.

Dr. Fellgett reports that Dr. Janine Connes of the Meudon Observatory near Paris, with her husband Pierre, refined his experimental technique so that it could be used to study astronomical objects with an extremely high standard of accuracy and reproducibility.

The French team did this by applying the mathematical technique called a Fourier transformation to the spectrum obtained when the two beams are combined in an interfering way. The Fourier operation is sufficiently complex so that a computer is necessary to decode the information contained in the interferometric spectrum.

Not only can it be done, but it is now being applied to scanning the planets, with a sensitivity for Mars and Venus about 100 times that previously available.

The MIFS is only one of several new devices sensitive to infrared radiation now being widely used, along with optical and radio telescopes, to explore the structure and composition of the universe at wavelengths previously inaccessible.

To exploit this kind of instrumentation, the astronomers would like to see a 1,000-inch telescope built by international cooperation, calling it a "very good bargain" at approximately $15 million, which is about one-tenth the cost of soft-landing a 30-pound instrument package on Mars.

The 1,000-inch telescope would be constructed of building blocks of 120-inch instruments, mounted circularly to feed a single focus. The first one built could be used separately until the next was completed.