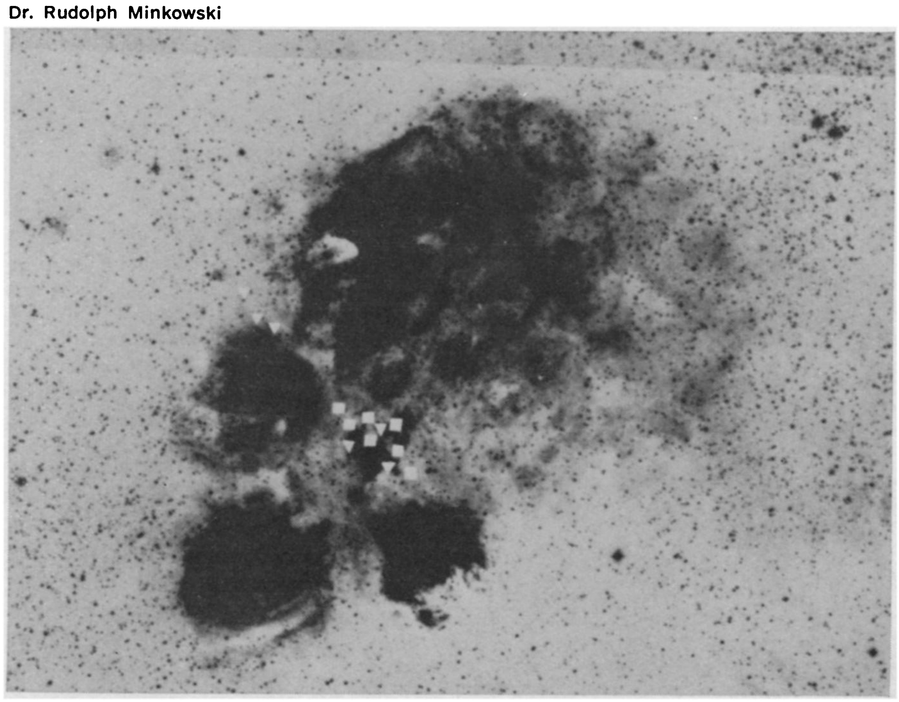
The search for molecules among the dust clouds

Interstellar grains may provide an ideal surface on which atoms can join

by Ann Ewing

Opaque cloud NGC 6334: a "dandy place for making molecules." White marks on negative print (below) are approximately where hydroxyl has been found.

Dr. Rudolph Minkowski



A photograph of an opaque interstellar dust cloud shows only a big black blob. But radio waves can penetrate otherwise impenetrable dust clouds.

Astronomers had their first look at the interiors of dust clouds five years ago (SN: 11/23/63, p. 323) when they discovered the radio radiation of the excited hydroxyl molecule. Detection of hydroxyl—one atom of oxygen bound to one of hydrogen and the first radio molecule found in space—was no surprise; its existence had been predicted theoretically. Molecular hydrogen, carbon, CH (a carbon-hydrogen combination) and cyanogen are among the other known molecular inhabitants of space.

Among them—and scientists are busy searching for others—are the basic ingredients for the precursors of life. This is one of the reasons an enthusiastic group of scientists is delving into a science so new it was named only this year: molecular astronomy.

The science can exist because a free radical—a molecule excited by external radiation as that from a star—emits a signature radiation identifying it when it drops to a lower energy state. This radiation may be either in the radio spectrum, as is that of the hydroxyl radical, or in the infrared.

Both infrared and radio radiation are able to stream through interstellar dust clouds which are opaque to visible light.

Many astronomers believe the clouds are made up of grains of silicon—plain sand—or of carbon. But whatever their composition, it is the surfaces of these

. . . interstellar molecules

grains that are of interest; they can provide ideal places for the production of molecules.

"An interstellar dust grain may be just a dandy place for making molecules; the grains, in fact, may be real molecule factories," says Dr. David D. Cudaback of the University of California, who, with Dr. George B. Field, is a midwife of the infant science.

This is because two atoms moving randomly in three-dimensional space have little chance of coming into contact with each other to form a molecule. If, however, they happen to be moving around on a surface, such as a dust grain, they are confined to two dimensions and the probability of contact is much greater.

Grain surfaces are not simply important places for molecules to form. A molecule on a grain can radiate its energy of formation more easily than it can in free space. This radiation reveals not only the molecule's presence, but also, by its specific wavelength, how it was formed.

Molecular astronomy has implications not only for understanding the creation of living organisms, in appropriate environments, but for the creation of solar systems in which such environments can evolve.

The theory begins where stars start to die—in the attenuated outer envelopes of red giants.

A red giant is an aged, swollen star. It represents a stage well along in the lifetime of an ordinary star, a stage at which the aging sun, for instance, several billion years from now, will expand from its present radius of some 430,000 miles to roughly a million miles.

This ballooning spreads a star's substance far and thin, and results in a temperature low enough for molecules to exist. Besides having a low temperature, the outer regions of red giant stars are very far from the center; gravitational attraction is very low and some of the molecules can escape into interstellar space.

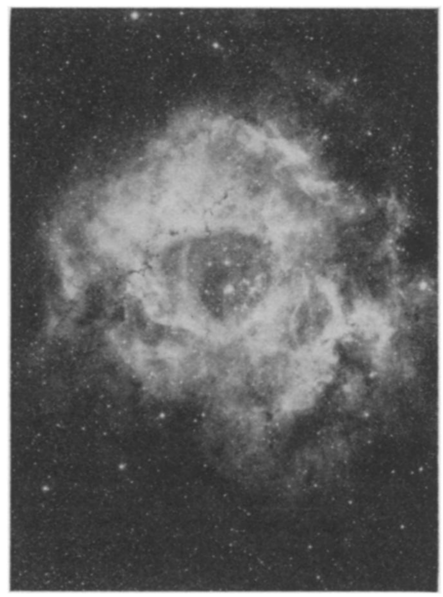
Gravitational attraction between escaped particles then causes this old/new interstellar material to condense; these condensations ultimately end up as new stars and, so goes the reasoning, new solar systems.

Astronomers are becoming more and more conscious of the condensation process and the regions where it seems to be taking place. Increasingly, they find evidence for objects that are not yet stars, but that are denser than the normal interstellar material.

All interstellar hydroxyl ions seem to be associated with the regions of such protostars. These stars-in-formation begin to heat up as they condense and, although their molecules are not yet being destroyed in the heating process, there is enough heat to generate infrared radiation.

Because infrared energy goes through the dust, the existence in the cloud of radiant molecules permits astronomers to study the light-obscured centers of the protostars.

Once the evolution has progressed as far as the formation of planets, if the theory holds, a planet should have in and on it samples of primordial, interstellar molecules. Although there is little observational evidence, Drs. Cudaback and Field believe molecules themselves evolve during the process. They suggest, in a draft plan for molecular astronomy prepared for their university, that as matter moves through the cycle from red giant atmosphere to planetary



Mt. Wilson and Palomar Observatories

Young stars in the Rosette Nebula.

system, the molecules become more and more complex.

If these molecules become sufficiently complex, they could affect the future evolution of other molecules on a surface. And if that surface is part of a planet—earth, for instance—such a hypothetical process could end as the curious molecular complex known as a man.

To test the hypothesis of complex molecules existing in interstellar space, Drs. Cudaback and Field suggest that direct experiments on fossil molecules on earth should be undertaken. Nobelist Melvin Calvin and Dr. A. L. Burlingame are now doing this for ancient terrestrial rocks and are planning to do the same when lunar material is brought back to earth next year.