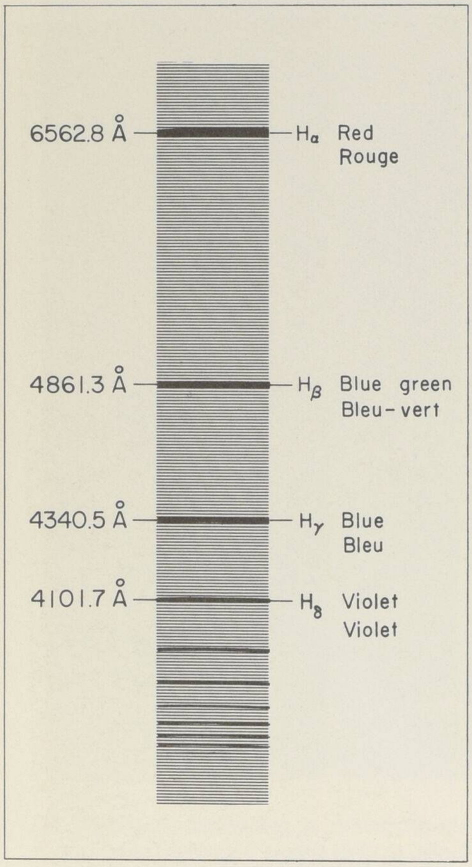
cosmic fingerprints



Fundamental example of the "fingerprints" used in spectroscopic analyses: the emission spectrum of atomic hydrogen (Balmer series). The spectral lines are identified by the wavelengths of the emitted or absorbed light measured in Angstrom units (Å), each equal to one ten-billionth of a meter.

Spectre d'émission de l'hydrogène atomique (série de Balmer) illustrant un cas d' "empreintes" de la matière obtenues par analyse spectrale. On identifie les raies spectrales d'après la longueur d'onde de la lumière émise ou absorbée mesurée en Angstroms (Å), unité de longueur valant un dix-millième de micron.

This former research professor from the University of Saskatchewan, who has been with NRC since 1948, was the first spectroscopist to discover and measure the spectra of some diatomic and polyatomic molecules. In addition to elucidating the structure of various commonly used compounds – carbon dioxide, oxygen, nitrogen and acetylene – Dr. Herzberg was the first to obtain spectra of several new molecules and radicals including the methyl and methylene radicals. He is the author of a four-volume series on atomic and molecular spectroscopy, works considered as basic reference texts by spectroscopists.

Although recently retired from his post as Director of the Division of Pure Physics of NRC, Dr. Herzberg is by no means about to withdraw from the scientific community. A few months prior to his retirement, it was announced by Dr. W. G. Schneider, President of NRC, that this internationally recognized pioneer in the field of molecular spectroscopy had been named a Distinguished Research Scientist, a position enabling him to continue research at the Council.

Many of Dr. Herzberg's studies at the Council have been conducted in co-operation with Dr. A. E. Douglas, who on Dr. Herzberg's retirement was named Director of NRC's Division of Physics, which combines the former Divisions of Pure Physics and Applied Physics.

The arches, loops and whorls of the cosmic fingerprints arise from the absorption or emission of energy, accompanying electron jumps from one energy level to another, or vibrational and rotational changes in molecules. Just as a prism breaks up the white light emanating from an ordinary light bulb into its component colors, and just as water droplets disperse sunlight into a rainbow, the prism in a spectroscope breaks up light from an emitting source (a neon bulb or a comet, for example) into lines and bands, characteristic of the atoms and molecules of the emitter. In contrast, the spectra of planets are almost exclusively absorption spectra. Sunlight reflected from a planet's surface passes through the planet's atmosphere, and the wavelengths associated with certain energies are absorbed by gaseous molecules yielding a characteristic pattern of dark lines on a bright background when the emergent light is analysed with a spectroscope.

The series of lines and bands in an emission or absorption spectrum are distinctive fundamental characteristics of the emitting or absorbing species just as are fingerprints for human beings. Both simple and complex substances can be made to yield their identities following stellar fingerprinting. Since the emitted and absorbed energies encountered in astrophysical investigations run the gamut of the electro-magnetic spectrum, studies are made in ultra-violet, infra-red and microwave, as well as visible spectra, involving different techniques, and yielding clues to differing parts of the puzzle.

From the beginning of Dr. Herzberg's career, the interplay of spectroscopy and astrophysics has fired his imagination. He stresses that the history of atomic spectroscopy abounds in examples showing the great influence that certain astrophysical problems have had on its development. Conversely, many advances in astronomy have resulted from new developments in atomic spectroscopy. Helium, first discovered in the solar atmosphere by spectroscopy and the recognition of the effect of relative motion of source and observer on the wavelengths of spectral lines (Doppler effect) were early examples of the interrelation between astrophysics and atomic spectroscopy. Dr. Herzberg notes paradoxically that spectroscopy was employed by astronomers Fraunhofer and Kirchoff more than a century ago to show that sodium was present on the sun. This was several years before it was used in chemical analysis.

Aside from his fundamental research into clarifying and resolving anomalies in the spectra of molecular hydrogen, Dr. Herzberg will continue to study one of the thorniest problems currently confronting astrophysicists – the origin of the diffuse lines in the absorption spectra of the space between the stars.

First discovered 30 years ago, these diffuse lines baffle astronomers. Most hold that these lines are produced by the interstellar dust, solid particles known to be present but which represent only one per cent of the mass of the interstellar medium. But they are unable to prove it. Dr. Herzberg, →