

Nicolet M & Aikin A C. The formation of the D region of the ionosphere.

J. Geophys. Res. **65**, 1469-83, 1960.

[Ionosphere Research Lab., Pennsylvania State Univ., University Park, PA]

This paper introduces the three essential sources of the ionization responsible for the formation of the D region of the ionosphere. Emphasis is placed on the differences between the various radiations. Evidence is presented for the simultaneous action of solar Lymanalpha radiation, galactic cosmic rays and solar X-rays required to account for normal and disturbed conditions. [The *SCI*[®] indicates that this paper has been cited over 135 times since 1961.]

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"This paper was one in a series of ionospheric papers published as a result of my work at the Ionosphere Research Laboratory of the Pennsylvania State University, where basic research on the upper atmosphere was developed in the early fifties under the direction of Art Waynick. It was my good fortune to arrive at the right place at the right time and to meet many people, in particular Art Aikin, who worked at that time with me for his Ph.D. Our paper dealing with the origin of the lower ionosphere came at a time when the field was expanding rapidly under the influence of the 1957 International Geophysical Year and the launching of the first satellites.

"Back in the bad old days, during World War II, I was working at the Belgian Meteorological Institute where 'active meteorology' was forbidden by the German occupation authorities, and I decided to study the physics of the ionosphere. At that time the study of the formation of ionospheric layers was still in its infancy and was, therefore, a basic problem. It happened that,

after my Ph.D. in astrophysics (1937), I was interested in developing a geophysical theory on the nature of the ions produced by solar ultraviolet radiation. As a result I began with the audacious hypothesis that nitric oxide – observed for the first time only in 1964 by C. A. Bath – was ionized by a powerful solar radiation; this I identified as the not yet observed Lymanalpha line of hydrogen, which must penetrate to the right altitude through an open window in the molecular oxygen absorption bands.¹

"Even though the germ of this idea was the result of hard work, it was, nevertheless, a stroke of luck that the paper (a French text of 162 pages!) was read by David Bates. He stated that my hypothesis seemed to be the only valid one, in a paper published in 1950.² This had the result of giving publicity to 'nitric oxide.'

"When I was at Penn State University, I had the privilege also of meeting Herb Friedman and his colleagues at the Naval Research Laboratory in Washington D C , who were observing solar X-rays and ultraviolet radiation with rockets. The solar X-ray observations were adapted to yield ionization rates of atmospheric molecular nitrogen and oxygen under different conditions of solar activity. This source of ionization was included with my own studies on the ionizing action of galactic cosmic rays,³ and the previously mentioned nitric oxide ionization to form a consistent theory of D-region formation and Art Aikin and I wrote the paper.

"In conclusion, it is gratifying to know that the ideas in the paper on the origin of the D region remain valid, and it is also rewarding to see that ionospheric research is still an active, expanding field, thanks to the new knowledge concerning ionic reaction and ion cluster formation."

1. Nicolet M. Contribution a l'etude de la structure de l'ionosphere. Institut Royal Meteorologique de Belgique. *Memoires* **19**: 1-162, 1945.
2. Bales D R & Seaton M J. Theoretical considerations regarding the formation of the ionized layers. *Proc. Phys. Soc. London B* **53**:129-41, 1950.
3. Nicolet M. Ionization by cosmic rays. Pennsylvania State University Ionospheric Research Laboratory. *Scientific Report* **102**:76-98, 1958.