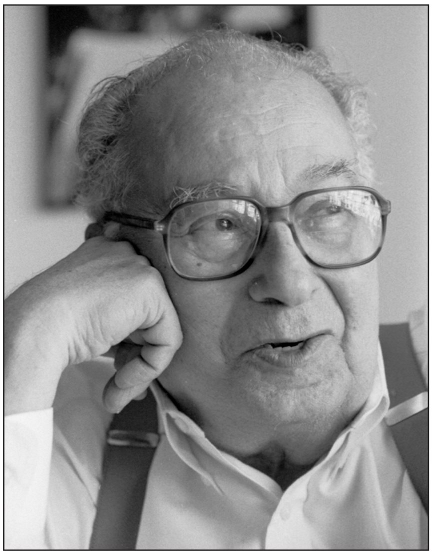
OBITUARY

Jules Aarons (1921–2008): Space Weather Pioneer

Prior to the use of the phrase "space weather" to summarize all possible effects of solar-terrestrial physics upon technological systems, the U.S. Department of Defense (DOD) created and maintained active programs in the application aspects of space physics. The person arguably most associated with those efforts was Jules Aarons, who died on 21 November 2008 at age 87 at his home in Newton, Mass. Jules was a research professor of astronomy and space physics at Boston University from 1981 to 2005, but it was as a civilian scientist at the Air Force Cambridge Research Laboratory (AFCRL) from 1946 to 1981 that Jules emerged as a true leader in studies of how the ionosphere can affect radio communications. He specialized in scintillations, those serious fluctuations of radio signal amplitudes and phases that cause dropouts in otherwise reliable communications links.



Jules Aarons

Prior to the space age, the Army, Navy, and Air Force required robust transmitter-to-receiver pathways for the high-frequency (3- to 30-megahertz) signals governed by ionospheric reflections. When the radar technologies developed during World War II evolved into the new field of radio astronomy, Jules promoted the use of celestial radio sources (such as the radio star Cassiopeia A) as trans-ionospheric probes of the regions on Earth where radio scintillations occur and the use of spaced receivers to study how the scintillations drift. When receivers were used at higher frequencies, the scintillations changed but did not go away, making it possible to study how different radio wavelengths probe the spatial scales of irregularities in the ionosphere.

Also prior to the launch of satellites, Jules and colleagues advanced the concept of using radio reflections from the Moon as a means of long-distance communications for DOD needs, as well as a way to study basic ionospheric structure. In addition to conducting experiments in the United States, Jules fostered international cooperation by arranging for U.S. support for the radio astronomy team of Bernard Lovell, Gerald Hawkins, and John Evans to conduct lunar reflection experiments at the Jodrell Bank radio observatory outside of Manchester in the United Kingdom. Their subsequent prominence in the fields of radio astrophysics, meteor science, and ionospheric physics, respectively, followed from equipment provided under Jules's auspices. The history of these internationally shared interests during the era of presatellite radio technology, and Jules's role in them, are described by *Butrica* [1997]. Jules's own linkage of the two fields is given in his monograph [*Aarons*, 1963].

Ultimately, the U.S.-U.K. synergies in radio work fostered by Jules contributed to Lovell's successful tracking of Sputnik 1 at Jodrell Bank. At Cambridge University, Jules's support of Antony Hewish's group fostered the high time resolution measurements of scintillations from interplanetary and interstellar plasmas that enabled the discovery of pulsars. Years later, when the Air Force decided to end radio astronomical work at AFCRL, Jules donated its 150-foot fully steerable radar to John Evans, who had by then established an incoherent scatter radar program at Massachusetts Institute of Technology/Lincoln Laboratory's Millstone Hill Observatory in Westford, Mass. A radar that could only observe in the vertical direction was thus replaced with one capable of broad latitude scans. Ironically, the Air Force's transformation of that facility into the premier ionospheric radar at midlatitudes worldwide, brokered by Jules, led to Evans's important research on the ionospheric disturbances that cause radio disruptions of relevance to DOD needs.

After Sputnik, when radio beacons were placed on board DOD and civilian satellites in low-Earth orbit, they provided only a few ~15-minute passes for data collection from a given site. It thus became necessary to create a network of ground stations to characterize the broad spatial scale of ionospheric influence upon their signals. At U.S. longitudes, AFCRL stations at the polar cap (Thule, Greenland), the auroral zone (Narssarssuaq, Greenland), the ionospheric trough/plasmapause region (Goose Bay, Labrador), the subauroral region (Sagamore Hill, Mass.), midlatitudes (Kennedy Space Center, Fla.), and low latitudes (Kingston, Jamaica) were all combined to study the dynamic patterns of ionospheric scintillations that occur during geomagnetically quiet and disturbed times.

Initially, Jules and colleagues concentrated on high latitudes and characterized the geophysical scintillation boundary that separated the normally structureless midlatitude ionosphere from the regions of auroral activity that caused scintillations. In later years, when DOD required reliable communications at low latitudes, Jules conducted the fundamental morphology studies of the seasonal/longitudinal/local time patterns of onset and suppression of the ionospheric irregularities known as equatorial spread *F*. Figure 1 gives the global view that summarizes these space weather contributions of Jules's career.

Complementing his work with scintillations, and to foster the understanding of radio navigation methods, Jules and colleague Jack Klobuchar used that same chain of stations to study the ionosphere's total electron content (TEC). TEC affects the time it takes a radio signal to travel through the ionosphere, and thus the Klobuchar-Aarons contributions set the stage for how today's Global Positioning System can be corrected for TEC-induced errors. The successful launch of geostationary satellites in the early 1960s provided stable paths through the ionosphere between space and Earth. The AFCRL chain created by Jules and coworkers provided the first set of coherent latitude patterns of scintillation occurrence and TEC storm patterns on the globe.

Mapping scintillation and TEC effects on a truly global basis required international collaboration, so Jules established the Joint Satellite Studies Group, which involved scientists and students from Europe, Asia, Africa, Australia, and New Zealand. This one-of-a-kind effort in global radio physics became the International Union for Radio Science Beacon Satellite Group, with symposia held every 2–3 years from 1970 to the present.

Jules Aarons is rightly remembered as a true pioneer of the space age. His work focused primarily on the radio communications needs of DOD, and to help meet those needs he established the premier DOD group to study the full solar-terrestrial system. He fostered basic scientific research on the same topics via strong involvement with university research groups in the United States and abroad. Using solar radio telescopes distributed worldwide for detection of flares, vast latitude and longitude chains of satellite observing stations for the study of the ionosphere and its variability, and his talent for guiding both young scientists and seasoned professionals, Jules Aarons helped formulate and carry out all of the basic ionospheric aspects of present-day space weather research.

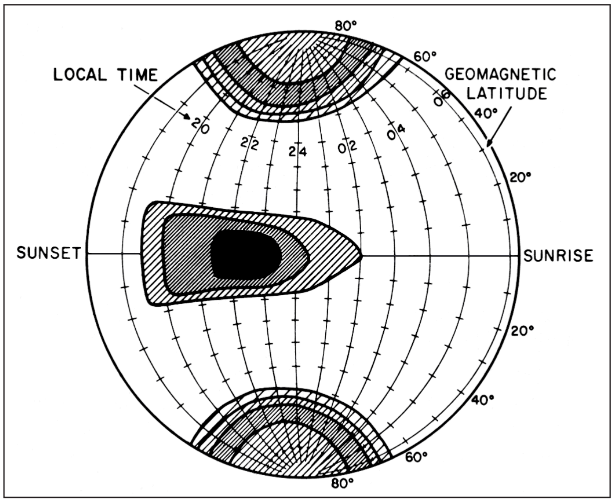


*Figure 1. The scientific image most associated with Jules Aarons. The figure portrays the global locations, local times, and severity of ionospheric radio scintillations [*Aarons*, 1982].*

References

Aarons, J. (1963), *Radio Astronomical and Satellite Studies of the Atmosphere,* North-Holland, Amsterdam.

Aarons, J. (1982), Global morphology of ionospheric scintillations, *Proc. IEEE,* 70(4), 360–378.

Butrica, A. J. (Ed.) (1997), *Beyond the Ionosphere: Fifty Years of Satellite Communications, NASA Hist. Ser., SP-4217,* Washington, D. C.

Michael Mendillo *is a professor in the Department of Astronomy at Boston University.*

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