Project Orion: The True Story of the Atomic Spaceship FREE

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Walter Baade, 'Arguably the most influential observational astronomer of the 20th century'

Walter Baade: A Life in Astrophysics

Donald E. Osterbrock
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Reviewed by Norriss S. Hetherington

In the autumn of 1943, Walter Baade, at the Mount Wilson Observatory, managed to resolve into individual stars the inner amorphous region of the Andromeda galaxy and two of its companion galaxies. The brightest stars were yellow giants; he found no highly luminous blue or red stars. Baade called the types of stars he found in the central region of the spiral galaxy and in its elliptical companions "population II," as distinct from "population I" or "ordinary" stars near the Sun in our Galaxy.

The discovery of a second stellar population opened up the fields of stellar evolution, star formation, and the evolution of galaxies and made Baade arguably the most influential observational astronomer of the 20th century. It made him perhaps even more influential than his more famous colleague at Mount Wilson, Edwin Hubble, who had demonstrated both the existence of independent galaxies and the expansion of the universe, and in doing so made cosmology an empirical science.

Baade was born in Germany in 1893 and studied at the University of Göttingen, in Germany, from 1913 to 1919. (A congenital hip defect kept him out of the war.) He then joined the Hamburg Observatory, which possessed a one-meter reflector, the largest telescope in Germany. Assistance from the Rockefeller Foundation enabled Baade to visit North America in 1926, with stops at Harvard University, the Yerkes Observatory, the Dominion Astrophysical Observatory, and the Lick Observatory and a six-month stay at the Mount Wilson Observatory. In *Walter Baade: A Life in Astrophysics*, Donald Osterbrock, a research astronomer turned historian of astronomy, meticulously documents Baade's life and work, with references to correspondence from more than 20 archives.

When documentary evidence is lacking—Baade was too diplomatic to express openly his impressions of American astronomy in 1926—Osterbrock guesses at Baade's thinking from his knowledge of the astronomy of the time and of Baade's attitudes. (The two were colleagues during the 1950s at the California Institute of Technology and the Mount Wilson and Palomar Observatories.) Osterbrock scrupulously warns readers of this necessary extrapolation and backs it up with reference to Baade's later and less guarded comments in lectures and colloquia.

At Hamburg, the industrious and meticulous Baade developed a wide observational experience with reflecting telescopes and showed great skill and resourcefulness. He was one of the most promising young astronomers in the world. Also, his personal characteristics had appealed to Mount Wilson astronomers. In 1931, Baade left Germany for a staff position at Mount Wilson—in the land of clear skies and big telescopes.

At Mount Wilson, Baade collaborated with Hubble in 1938 and 1939 on a study of the Sculptor and Fornax dwarf galaxies. The astronomers found neither blue nor red supergiant stars in the two systems and noted that "as a working hypothesis" it could be assumed that supergiants were lacking in elliptical galaxies. However, "discussion of the data now available would be largely speculative, and hence of little permanent value." Osterbrock attributes the hypothesis to Baade and the caution against speculation to Hubble, who was absent from Mount Wilson during World War II. Baade—a German citizen, excluded from the US war effort—was thus left free to prove that the same supergiant-free population of stars is present in the dwarf elliptical companions of the Andromeda galaxy.

There is more to the advance of science than new observations and new theories; ultimately, people must be persuaded. Baade's subsequent work and talks at meetings convinced astronomers of the existence of two stellar populations.

Baade's discovery was a completely empirical result. A few theoretical discussions occurred during the early 1940s regarding the possibility of two stellar populations as manifestations of early and late stages of stellar evolution, but those discussions were not known to Baade. They did not, however, escape Osterbrock's thorough study. Also impressive is Osterbrock's exploration of the astronomical community's behind-the-scenes intervention to squelch Harlow Shapley's shameless attempt to claim credit for the doubling of the scale of the universe that followed from the recognition of two stellar populations.

Osterbrock has achieved his stated aspiration: to present known facts in interesting and readable form. Fortunately, he has exceeded his intention to leave readers to draw conclusions. He has focused on hitherto unknown or overlooked facts, shown why they are important, and created a new understanding. This is the essence of good history.

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Project Orion: The True Story of the Atomic Spaceship

George Dyson
*Henry Holt, New York, 2002. $26.00 (345 pp.).
ISBN 0-8050-5985-7*

On 4 October 1957, the Soviet Union surprised the world by launching Sputnik. We are fortunate to have George Dyson's beautiful account of an episode that captures the spirit of America's successful response to this challenge. Project Orion—a proposed nuclear-energy-based space propulsion system—was never allowed to progress to any meaningful test.

However, Dyson's portrayal of the boldness of the concept and the enthusiasm of the scientists involved provides a deeper insight into the latent power of an aroused free society than the histories of successful but less imaginative projects.

Chemically fueled rockets, with their low energies per unit volume, require two or three stages, with costs currently about $10 000 per kg of payload, to achieve low Earth orbit. Thus chemical rockets have been practical only when payloads have great economic or political value per unit weight. That restriction inspired several attempts to use nuclear energy for propulsion. One of the more imaginative suggestions was Stan Ulam's: that a small nuclear explosion at an appropriate distance from a space vehicle could vaporize a renewable surface layer on a "pusher plate," and thus could be used for propulsion. Since the evaporated material would be heated to temperatures much higher than are attainable from chemical reactions, much higher propellant velocities could be achieved. Repeated small nuclear explosions would enable high spacecraft velocities. The availability of higher propellant velocities would release designers from the severe restrictions and high costs of the chemically powered space program. The Solar System could be explored with manned round-trip voyages.

Project Orion was organized in 1958, on the heels of Sputnik, to realize these possibilities. Ted Taylor, Freeman Dyson, and many other distinguished scientists devoted themselves to Orion for years. The Defense Department's Advanced Research Projects Administration (ARPA), by far the most imaginative of the government's supporters of research, financed the start of Orion with a $1 million feasibility study.

George Dyson, Freeman's son, reproduces many of his father's letters to his parents, which, although limited to unclassified material, convey much of the excitement of this creative project. Freeman retained his enthusiasm for Orion until 1959, when he convinced himself that the radioactive byproducts deposited in the atmosphere and the magnetosphere might result in about one more cancer per mission in Earth's population. He considered this cost too high. The others carried on with somewhat reduced enthusiasm.

The critical time for project Orion came at about the time of John F. Kennedy's election to the presidency in 1960. NASA had rejected Orion, saying "It would be extremely difficult to divert funds from nearer-term projects for the support of Orion. We would not therefore, favor any arrangement requiring such support." ARPA turned to the US Air Force, which found that it could squeeze Orion in, despite the ordinary restriction of the air force to projects meeting military requirements. Taylor and the other Orion scientists managed to keep the project sputtering along until 1965.

The late Trevor Gardiner, assistant secretary of the air force, headed a committee (of which I was a member) formed to propose a response to Sputnik. That committee issued an unclassified report in March 1961, saying that "nuclear propulsion may more than double the specific impulse attainable while still maintaining high thrust-to-weight ratios and could make possible the utilization and exploration of space on a truly vast scale."

Vice President Lyndon Johnson controlled all space matters; the unclassified Gardiner Committee report apparently did not fit his plans. He declared it "Top Secret" and ordered all the copies to be kept in his safe. This action squelched all but the space initiatives that were to be located in the states of LBJ's Deep South constituency. I repeatedly requested the release of the Gardiner report under the Freedom of Information Act, and finally was successful in 1995. In addition to nuclear energy proposals, the items suppressed included Earth-orbital assembly schemes using available chemical rockets (similar to the suggestion by Taylor et al., which Dyson describes on p. 218). I have no doubt that those proposals would have fulfilled Kennedy's moon landing commitment sooner and more cheaply than the plan LBJ approved. But even more important, they would have given us a much more exciting space program.

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Atom Optics

Pierre Meystre
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By the middle of the 20th century, light–matter interaction physics (optics) was finally established. Following the progress made in studying statistical effects in radio electronics (radar, communications), the development of statistical optics and coherence effects was coming to a close. Nobody could believe that optics would return from the physics rearguard to the forefront.

The discovery of the laser, perhaps one of most important scientific instrument developments of the past century, brought optics back to prominence. There followed the discovery of nonlinear optics, coherent optics and holography, quantum optics, and finally atom optics. In atom optics it is not that atoms affect light but that light exerts an effect on the state of motion of atoms, and the atoms themselves behave like waves. In this process the particle–wave dualism becomes a vivid manifestation of interrelation and unity in nature. I experienced a true sense of the beauty of physics when I started working in this field a few decades ago. It was perhaps at that time that I came to believe that laser light could do literally everything. And now that laser physicists are advancing toward the realization that light can not only control matter but also create it, by super-intense femtosecond pulses, I may turn out to have been right.

Atom optics today has reached maturity: It has become both wave (coherent) and nonlinear atom optics. Of course that expansion required generalization in a new book. Pierre Meystre has taken just such a generalist approach in his timely *Atom Optics*. His were the pioneering works in atom optics; to get information from the first explorer is always most valuable to the reader. (I tried in 1995 to summarize the first stage in the development of atom optics, geometrical atom optics in the main, in a small book written in collaboration with Viktor Balykin: *Atom Optics with Laser Light*, Harwood Academic.)

Meystre's book consists of three parts in logical sequence: linear, geometrical, and wave atom optics; nonlinear atom optics; and quantum atom optics. The first part generalizes the most thoroughly developed area of atom optics. The author next turns to the new aspects that have just started to be developed, largely under the influence of his work; the contents of the second and third parts are addressed to future researchers in nonlinear and quantum atom optics.

It is very important that the author considers collisional effects in atom optics, especially in the atom laser, in which they play a dual role. The characteristics of a photonic laser always grow better and approach the ultimate as the occupation number n of