

"There is nowhere to go but up and out"

The High Frontier: Human Colonies in Space

G. K. O'Neill
288 pp. William Morrow, New York, 1977.
\$8.95

Space Settlements: A Design Study

R. D. Johnson, C. Holbrow, eds.
185 pp. USGPO, Washington, D.C., 1977.
\$5.00

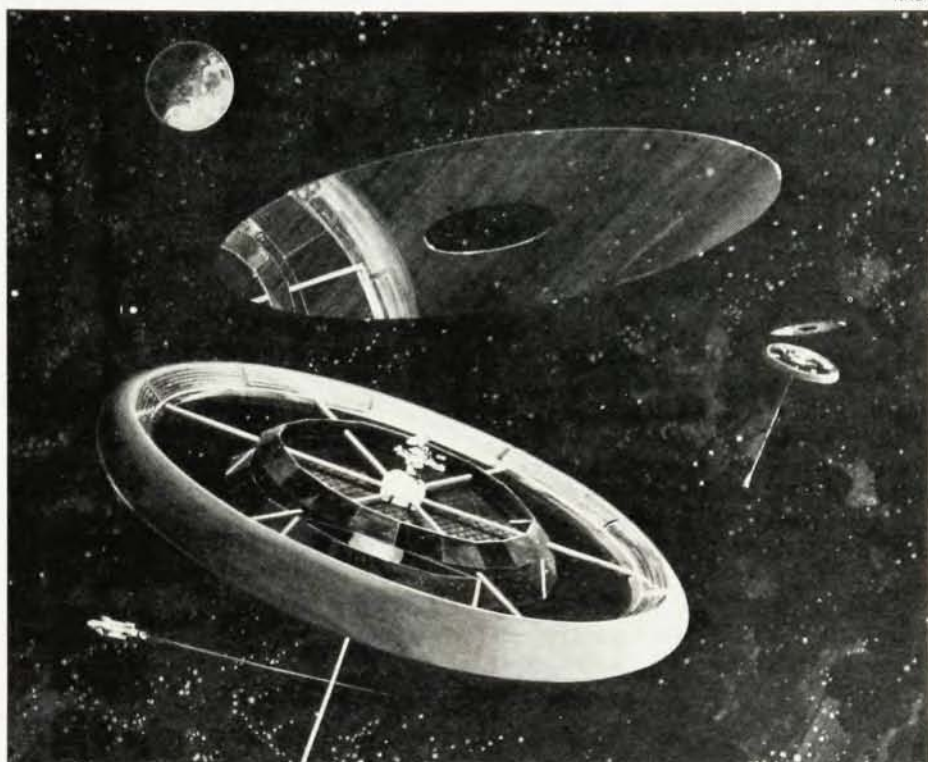
Colonies in Space

T. A. Heppenheimer
224 pp. Stackpole, Harrisburg, Penn., 1977.
\$12.95

Colonies in Space: The Next Giant Step

F. Golden
145 pp. Harcourt Brace Jovanovich, New York, 1977. \$8.95

Reviewed by Philip K. Chapman



Exterior of a space habitat for some 10 000 people. The drawing is from *Space Settlements: A Design Study*, a book that gives engineering and economic detail about this particular design.

In September 1974, Gerard K. O'Neill, a high-energy physicist at Princeton University known mostly for his contributions to storage-ring accelerators, published an article in this magazine on the colonization of space. The furore has mounted steadily ever since. The question he posed was simple but fundamental: If we are going to live off Earth and have climbed laboriously out of the geopotential well for that purpose, why climb laboriously down into the potential well of some other planet? Why not live in free space? His conclusion was that it is feasible (in an engineering sense, at least) to build, in free fall, self-sufficient habitats that could be large enough to house populations ranging from several thousand to several million people in suburban comfort. Construction materials could be obtained from the Moon or from the asteroids at a transportation cost much lower than that from Earth and without depleting terrestrial resources. Artificial gravity could of course be provided by

spinning the habitat at a suitable rate.

Whatever view one may take of the practicality of these bold proposals, it should be recognized that O'Neill has started a movement in this country and especially on the college campuses, of a magnitude comparable to the ecological or anti-war movements of the 1960's. His singular achievement is that he has aroused enthusiasm and dedication, not in opposition to some perceived evil or inequity, but in favor of a positive goal: that of human migration into space. The largest and most influential of the organizations that have sprung up in response to the challenge of space colonization is the L-5 Society (so named because O'Neill's original proposal was to locate the first colony at the equilateral Lagrangian point L-5 of the Earth-Moon system) whose stated purpose is "to dissolve itself in a plenary session to be held at L-5 as soon as possible." The membership ranges from fans of "Star Wars" (a category including everybody except perhaps

Stanley Kubrick) to planetary scientists, aerospace engineers, economists and politicians. The emerging power of the movement for a greatly expanded space program was clearly demonstrated last July, when the House Appropriations Committee deleted funds for the Jupiter Orbiter Probe from the NASA budget. After a hastily arranged call-your-Congressman campaign, the full House restored the Probe by a vote of better than 2 to 1. In California, Governor Jerry Brown has become a convert, recognizing expansion into space as probably the only way to reconcile the need for economic growth with the need to conserve this fragile little planet.

It is easy to argue with the scenarios for exodus assumed in these books, but they may not reasonably be dismissed as fantasies. In *Colonies in Space*, Tom Heppenheimer quotes Arthur Clarke: "If Man survives for as long as the least successful of the dinosaurs . . . then we may be certain of this: For all but a van-

ishingly brief instant near the dawn of history, the word 'ship' will mean 'space-ship.' If we can avoid collective suicide long enough to get the starships built, in a thousand years there will surely be human settlements orbiting a hundred suns in our corner of the Galaxy, and the race will be immortal.

Our generation may stand at a crucial breakpoint in history, for we in the presently affluent nations may be the last who can afford to open the high frontier. What we do during the next ten or twenty years may determine whether future generations will live in a humane and rewarding society, or whether they will spend their lives in desperate contention for the dwindling sustenance afforded by our limited terrestrial resources. We have reached the ends of the Earth, and there is nowhere to go but up and out. The technology is at hand for getting the costs of space operations down to a level comparable to those of a long-haul airline, and we clearly should be moving ahead much more vigorously.

It is unfortunate that there is dissension in the movement between the conservatives, who merely want an orderly investigation of the feasibility of space industrialization (for example, an investment equal to perhaps 1% of the annual US bill for imported oil, to find out whether satellite solar power stations make economic sense), and the radicals, who insist on a "lunar mine by '89" or on the priority of colonies over industrial facilities. There are even schisms between advocates of particular technologies, which is quite absurd at the present stage of development. What is important is to get the space program moving again while there is still time and funding available for it to contribute what it can to the future of Man, not whether one is a believer in the gospel according to O'Neill.

The books listed above present some diversity of opinion on these issues, but they all draw heavily on the ideas of O'Neill. For example, they all argue strongly for the use of extraterrestrial resources (lunar or asteroidal) in the construction of solar-power satellites. It is probable that, in the long run, this will make economic sense, but the power satellite is a mind-boggling concept in itself: To hold that a lunar mine is a necessary precursor is to create a program of such staggering scope as to preclude funding by a skeptical Congress.

Of the four books, the NASA Special Publication *Space Settlements* (SP-413) provides the most thorough engineering and economic detail about a particular space-habitat design (now known as the Stanford Torus). It is the report of the 1975 NASA-ASEE Summer Study at NASA Ames Research Center. The book is very well produced, with excellent graphics and artwork, far above the standard of most such reports. On the

whole, though, I would recommend the book by Heppenheimer (who was a participant in the 1975 study) as the most readable and comprehensive introduction to the subject. His final chapter, a reasonable discussion of the feasibility of interstellar colonization, is particularly interesting: I wonder what the reaction is in the Department of Energy to the revelation that research on laser-induced thermonuclear fusion is directed, not towards generating electrical energy, but towards a starship drive.

The High Frontier provides a more carefully reasoned (but not necessarily more convincing) rationale for space colonization, and is useful also because of its account of the history of the movement during the last few years. Frederic Golden's book covers much the same material in a rather more journalistic fashion, and I would judge it most useful to a younger audience.

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Philip K. Chapman, a former scientist-astronaut, is currently working at Arthur D. Little, Inc., on development of the satellite solar power station concept.

An Introduction to Regge Theory and High Energy Physics

P. D. B. Collins

445 pp. Cambridge U.P., New York, 1977.
\$59.50

Physics in the angular-momentum plane (Regge theory) has undergone a remarkable explosion since its modest beginnings some fifteen years ago. We have come to understand the deep connection between observed hadron states and the power behavior of cross sections. We have learned of the beauties of duality and, through generalizations of that, begun to think of hadrons as "strings"—a concept that promises to connect Regge theory with underlying quantum field theories such as quantum chromodynamics. We have discovered how unitarity requires the familiar Regge poles to appear in kinematically rich inclusive reactions, thus providing a unifying theme to vast quantities of hadron-scattering and production data.

For the student or researcher to learn of these achievements has been a formidable task. The material is spread over years of the *Physical Review* with an occasional "up to date" review article available. The present monograph by P.D.B. Collins of the department of physics, University of Durham, UK, addresses the need for a coherent introduction, both to the tried pathways and to many of the mysterious tracks of Regge

physics. The author has previously written two reviews of this subject, both valuable to workers in the field. In this book he goes out to a more general audience and provides in clear, forthright fashion the background necessary for the serious student of hadron physics to "come up to speed" as a research person, and at the same time he offers the established research person an extremely useful compendium of the important contributions and ideas made in Regge theory in the past decade.

This monograph is impressive in its completeness. Donning my reviewer's hat I set out to be enormously critical of the work. I was able to come up with several fairly trivial comments. For example, the key idea of the Pomeron is attributed to Geoffrey F. Chew and Steven Frautschi; Vladimir N. Gribov's publication of the idea in the same month (June 1961) is ignored. Also, the connection between power behavior of hadronic scattering amplitudes and resonances was very clearly made in a classic paper by Richard Blankenbecler and Marvin L. Goldberger. The absence of reference to their work seems surprising. And another trivial point: The casual surveyor of the table of contents will be most amused to find chapter 6 labeled as the "Introduction."

My major critical comment on the book concerns the order of presentation of the material. The reader is led through a very heavy dose of S-matrix theory, helicity-amplitude technology, properties of second-kind rotation functions, Sommerfeld-Watson transformations and the like before emerging in chapter 5 into the important physical facts of hadron scattering at high energies. Since the latter is absolutely fundamental to the physical interest of the former, I would have preferred the author to have presented the rudiments of the theory first, then the experimental facts, and then the heavy-duty formalism. The dedicated reader will, of course, get to all the important substance. One worries about the less hardy.

In addition I feel there should be included in each chapter several sections attempting to state in physical terms either the key ideas touched on or the reason for covering the material. Scientific writing too often follows the principle of punitive pedagogy: repeat the important points as often as the unimportant ones—once. An "Introduction to..." should be more than a review of material past while stopping short of being a students' text. In the chapter on "Some Models Containing Regge Poles" (chapter 3) the author forbears informing the reader that a crucial ingredient in generating Regge poles is a cutoff in momentum transferred to produced particles, and comes within a micron of revealing (page 98) that a Regge pole is a generalized bound state of hadrons—with gen-