are. The real issue is whether Bohr would deliberately and dishonestly use his authority to intimidate others into accepting a position that he did not believe to be true.

Beller takes great pains to show that Bohr was not at home with difficult mathematics, and she uses this to imply that he was actually, deep down, sort of a bumbler. She even calls him "a tragic figure," who should not have been taken so seriously by so many great physicists. But truly great insights in physics rarely come primarily from mathematical sophistication, and I find her arguments somewhat irrelevant to the issue of how much respect Bohr is due. Einstein, who never accepted Bohr's interpretation of quantum theory, called Bohr's insights "the highest form of musicality in the sphere of thought." (This quote is not from Beller's book, but it is hard for me to see intimidation at work here.)

As a parallel case, I remember when I found out that Irving Berlin could not read a note of music. Rather than convince me that his songs were no longer worth listening to, this made me appreciate all the more what a phenomenal natural genius he must have been. My reaction to Bohr's mathematical deficiencies is similar.

Also, many of Beller's other arguments against Bohr depend on accepting her reading of very weak evidence. There is just no smoking gun here. When one reads everything someone has written over several decades, it is easy to find shifting opinions, contradictions, and confusing remarks. This does not necessarily make a case for intellectual dishonesty. Nor does trying to use different strategies of argument, geared to different types of audiences, prove that one is disingenuous. I think Beller is guilty of trying to force the worst possible conclusions out of very slight and ambiguous evidence. The problem is that she has not approached her subject with a very open mind. One can begin to see her bias in comments such as "One interesting attempt to find some stability, objectivity, and cohesion, despite the impressive impact of social studies of science that deny those characteristics to science, is..." This jaundiced look at science in general leads to such opinions as "finality is an ideological, not a conceptual, position, and this is perhaps the reason scientific controversy often looks more like a political campaign, with one side discrediting and caricaturing the other, than an open-minded dialogue about fundamentals."

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So what is one to make of *Quantum Dialog*? The author makes a good case for the contention that arguments about the consistency of the Copenhagen interpretation came to support the incorrect conclusion that it was the only possible interpretation. How could this happen? I think this is a fascinating question, well worth a book. But I also think that it is a serious mistake to look for villains. That makes the process much simpler and less significant than it was. The problem becomes much more interesting and important when one sees the process unfolding and asks how could so many people, all looking for the truth, have convinced themselves that one viable interpretation was actually unique and unassailable.

It is easy to construct a much more conventional and, to my mind, plausible scenario as to how this occurred, one without conspiracy theories. Furthermore, scientists like to believe that the scientific enterprise is a self-correcting one. And although there is nothing inevitable in the process, in the case of quantum theory, one can see the corrections slowly taking place. The original Copenhagen interpretation had a tremendous formal mathematical beauty, and Von Neumann had "proven" that a hidden variable interpretation was not viable. So it is easy to see how most physicists accepted this and considered the matter closed.

Only in the 1950s did Bohm invent his alternate model, which led John Bell to disprove Von Neumann's result. (Beller mentions a previous argument against Von Neumann's proof by a student of Heisenberg, but because she doesn't give any details, one cannot evaluate its merit.) Bell then also proved his own famous theorem, which showed that one can experimentally test certain types of realistic interpretations. This not only led to a series of still-ongoing experiments to test aspects of various interpretations, but it also increased interest in the possibility of other interpretations. Since then, Bohm's interpretation and several others as well have slowly been winning converts. Many philosophers have become interested in the new models. In general, the situation is now much more favorable for the acceptance of new models than it was in the past, although none have yet caught on among working physicists, mostly because there are no new experimental situations that have needed to be explained by them. But in this history, one can see the gradual development of an open-mindedness in the field.

Scientists unfortunately do jump on bandwagons and make flawed judgments, and this does slow the process of choosing between theories. But in this case the process does seem to be slowly correcting itself. There is no necessity for seeing dark forces at work here or for impugning the character of the scientists. Making Heisenberg and Bohr into villains doesn't ring true and doesn't solve the interesting problems involved. (Of course, Beller is fully aware of everything I have said above, but she would certainly not agree with me. To the extent that one denies objectivity to science, "self-correcting" becomes a meaningless concept, and one is forced to find more sinister explanations based on the foibles of individuals.)

EXHIBITIONS: ART AND ASTRONOMY

Views of the Final Frontier

Jay M. Pasachoff

From the 19th-century movement known as Romanticism through the early 20th-century Avant-garde and now into the 21st century, artists' perceptions of the cosmos have continued to evolve. The plurality of worlds foreseen by Giordano Bruno (the 400th anniversary of whose death was marked this February) found its way into the Russia of the 1920s. One result of this trajectory is a strange room created by Ilia Kabakov in the 1980s, with walls covered in Cyrillic posters from the Soviet era and with pages of typewritten text describing a purported escape from the Soviet Union to outer space from an in-house rocket explosion. The room is one feature of the exhibition *Cosmos* and its accompanying book, both of which present a fusion of science, art, politics, and humanistic thought. The utopias in space imagined by Russian writers after their revolution are discussed in one of the book's essays.

Cosmos
From Romanticism to the Avant-Garde
Jean Clair, chief curator, and Pierre Théberge, director

At the Montreal Museum of Fine Arts, 17 June to17 October 1999; Centre de Cultura Contemporània de Barcelona, 24 November 1999 to 27 February 2000; Palazzo Grassi, Venice, 25 March to 23 July 2000.

Cosmos
From Romanticism to the Avant-Garde
Jean Clair, Ed.

Published for the Montreal Museum of Fine Arts by Prestel, New York, 1999. 396 pp. $75, £45. ISBN 2-89192-231-X.

The exhibition is a remarkable amalgam of paintings, photographs, books, sculptures, and other artifacts. I saw it in Barcelona, where the contents differed somewhat from the original presentation at the Montreal Mu-

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seum of Fine Arts. A third version of the exhibit, with a new subtitle (*From Goya to De Chirico, from Friedrich to Kiefer; Art in Pursuit of the Infinite*), opens in Venice this week. Half the works shown there will be new additions, among them two Turners and more pieces by symbolists and Italian futurists. Readers with an interest in the overlap of art and science should seriously consider a weekend trip to Venice—never a hardship—for this show alone.

Among the many works that struck me with special force were paintings by Joan Miró (the sun setting over a landscape and selections from his "Constellation" series) and a sculpture by Alexandr Rodchenko in the form of a decayed armillary sphere, shadowed on the counter below. A 30-cm-high bronze star by Jean Arp, standing upright on two points, was more remarkable than a 3-m-wide bronze-colored circle in foil that marked the exhibit's opening salvo. Many of the paintings and sculptures in the exhibition's second section (of three, as presented in Barcelona) had an astronomical theme, though the inclusion of a few paintings (apparently linked only by their containing many circular shapes) seemed far-fetched. Alexander Calder's addition of a ring around a circle, to make Saturn, was more persuasive.

Joan Miró's *Sunrise*. From his "Constellation" series, 1940 (Varengeville, January 21).

CREDIT: TOLEDO MUSEUM OF ART

For me, the highlight of the exhibition was a small dark room. One wall held a very early photograph of the sun by Fizeau and Foucault from 1845, only six years after Daguerre's process was explained to the French academy. Because I spend much of my time advising about eye-safety precautions to people in areas where solar eclipses will soon occur, it was remarkable to realize that even the long exposure tried on the primitive daguerreotype plate barely brought forth a circular image. A second wall of the room had a series of seven daguerreotypes of the 1854 solar eclipse; only partial phases were captured, but one shows the thinnest of crescents. On a third wall hung one of the John Adams Whipple daguerreotypes of the moon captured with the Harvard College Observatory's "Great Refractor" in 1851, already showing as much detail of the moon as we might associate with more recent photographs. The noseprints on the protective glass in front of the daguerreotype showed just how attractive people find this image. On a long wall outside the darkened room were mounted a variety of photographs of the moon, including Lewis Rutherford's New York City image of 1865 and 1967 Lunar Orbiter views of a crescent Earth rising above the lunar surface. A large-format print of a photography by Eugene Cernan (the last person to stand on the moon) showed his colleague Harrison Schmitt (the only scientist to have walked on the moon), with only the golden tinge of the Lunar Rover's antenna revealing that the 1972 photo was in color rather than in black-and-white.

The theme stressed by the exhibit's organizers (obviously not scientists) was how the cosmos of Romanticism involved travels to the ends of the Earth (namely, the North Pole) and how the closing of terrestrial frontiers led explorers and visionaries into space. A wall of photos from the 1870s by Carleton Watkins and others showed images that started the movement that led to the establishment of national parks in the United States. A huge Yosemite landscape by Albert Bierstadt captured the frontier at its most beautiful. Other views of Yosemite mountains included a 1865 photograph by Charles Leander Weed with a lone tree on the Mariposa Trail, which segued into an oil painting by Emily Carr of a similar tree on an adjacent wall. Among the exhibition's other fascinatingly revealing groupings were a wall of oil paintings of arctic icebergs, a wall with paintings of auroras, and a wall bearing a pair of Niagara Falls images.

The exhibition is accompanied by a massive and lavish coffee-table volume, which was edited by Jean Clair, director of the Musée Picasso in Paris. This catalogue contains essays by a half-dozen individuals interspersed with well-reproduced photographs. The authors advance troubling interpretations of some of the paintings, perspectives I would not have noticed with my scientific, positivist orientation. For example, I noted the oil painting by Goya of Montgolfier drifting over Paris in his first balloon but did not myself realize that the people below the balloon were fleeing in terror. Alfred Stevens's 19th-century oil *The Milky Way*, showing a woman in a window with the stars over the sea behind her, was a more benign canvas. Fortunately, by the end of the exhibition, the relationship of the people to the science of the cosmos was generally friendly.

The illustrations in the catalogues are well reproduced and include a large percentage of the objects displayed in Barcelona. (Separate editions of the catalogue have also been published in French, Spanish, and Italian; these display the respective versions of the exhibit.) But the third dimension available by attending the exhibition was sometimes invaluable. The catalogue photograph of a work by Claudio Parmiggiani, for example, shows a ladder leading through a dodecagonal window into a starry frame; the art included a real, three-dimensional ladder. The exhibit's final piece, a striking sculpture by Vladamir Skoda with a spherical pendulum bob swinging back and forth before a focused light to form a constantly varying eclipse, lost its intensity on a static page.

The exhibit's final flat images were huge astronomical photographs of star fields. These might have been more striking to those not familiar with the normal beauty of astronomical plates. Painted views of the sky by Vija Celmins, who has been asked by NASA to translate Hubble Space Telescope images into art, were more remarkable. A slide show of David Malin's images of color nebulae appeared on a wall on the way out. Perhaps the organizers were not sufficiently knowledgeable of contemporary astronomers' current imaging capabilities to include the Hubble Deep Field images or some of the new photographs of celestial objects from the European Space Agency's Very Large Telescope in Chile.

Both the exhibition and the book present informative blends of art and science that should interest a wide range of people. Although many will find it easier to arrange a perusal of the catalogue, I found the exhibit in Barcelona well worth a cross-Atlantic trip. The version in Venice, with its many newly included pieces, should be equally rewarding.

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