was massive funding for particle accelerators. But since accelerator physics lay outside the purview of both meetings the omission is understandable.

Taken together, *The Birth of Particle Physics* and the proceedings of the International Colloquium make fascinating reading for anyone interested in the intellectual and social formation of elementary particle research. The Fermilab volume is better produced and edited, and Brown and Hoddeson's introduction provides a much-needed synthetic perspective, but the Paris volume covers a wider range of topics. The organizers and speakers at both meetings are to be congratulated. But a caveat is nevertheless in order. On one key point of interpretation, the vision of history offered by the scientists needs to be challenged. It concerns the relationship between theory and experiment in the 1930's and 1940's and, in particular, the sources of theorists' reluctance to countenance the existence of new particles.

Certainly such resistance was manifest. In the mid-1930's, for example, data on the "penetrating component" of the cosmic ray flux were hard to reconcile with QED, but theorists like Bohr and Oppenheimer preferred to ascribe this to a failure of QED rather than to the existence of a new particle (later, the muon). Yukawa's prediction of the pion was at first widely ignored in the West. Eventually the "Yukon" was identified with the penetrating cosmic ray component, despite considerable discrepancies between predictions and observations. There followed a decade of confusion, only resolved in 1947 with the two-meson hypothesis—the idea that there were not one but two new particles, the muon and the pion, and that both were to be found in the cosmic ray flux.

Time and again, at Fermilab and Paris, theorists asked themselves why they had been so reluctant to acknowledge the existence of the muon and the pion. And repeatedly they responded with a doctrine of psychological resistance: we lacked the courage to accept the possibility of new particles. This explanation does not ring true. It is hardly conceivable that the men who advanced quantum mechanics, leaving the foundations of classical physics in tatters behind them, should have been held back from proposing the odd new entity by fear (of what?).

The history of the living seems here to slide into myth. Far more plausible, given the background of the leading theorists of the day, is that the existence of new particles appeared to them at most tangential to their enterprise. They were in the business of building new systems, and, having laid the foundations of quantum mechanics, they felt that it was time to move on. Apparent failures of QED were *welcomed* as clues toward the structure of its successor. Many historical instances of this latter attitude are to be found in the Fermilab and Paris volumes, sitting uneasily alongside assertions of psychological inhibition. And it is noteworthy that the "boldness" of Japanese theorists in proposing the existence of new particles—Yukawa's prediction of the pion was just the beginning—can be directly correlated with the isolation of Japan from the main centers of theoretical authority in Europe and the United States. The Japanese had no Bohrs or Oppenheimers breathing down their necks. (On the positive side, the role of Taketani's Marxist epistemology in encouraging the invention of new particles also deserves attention: see Takabayashi's contribution to *The Birth of Particle Physics*.) The history of the dead has bequeathed us enough myths; we should be wary of new ones offered by the living.

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Newton

In the Presence of the Creator. Isaac Newton and His Times. GALE E. CHRISTIANSON. Free Press (Macmillan), New York, and Collier Macmillan, London, 1984. xvi, 624 pp., illus., + plates. $27.50.

In the wake of Richard S. Westfall's widely acclaimed *Never at Rest* (Cambridge University Press, 1980) comes another, only slightly less massive, biography of Isaac Newton. Since comparisons are tempting, it is important to signal at the outset the essential difference between the two works. Westfall's is a scientific biography. It keeps continuing focus on Newton's science and on the manner in which his ideas arose and matured. A magisterial account, it draws its strength from Westfall's own original contributions to historical scholarship concerning Newton's optics, the development of mechanics from Galileo to Newton, and the relations of science and theology. By contrast, Christianson speaks only second-handedly of Newton's science, turning for judgments in that realm to Westfall and the other scholars who over the past quarter century have done so much to open that solitary genius to critical examination.

In the Presence of the Creator constitutes a popular biography, a "life and times" that uses the stages of Newton's scientific development essentially as points of departure for essays into his personality and into the people, institutions, and locales that surrounded him. Although Christianson offers no new insights, he does present a thoughtful, balanced picture of a genius tortured by self-doubt. The conditions of Newton's birth and his obviously unusual mental powers gave him a sense of special election, while the circumstances of his upbringing and his rigorous and continuing self-criticism engendered a feeling of unworthiness. The resulting tension, as Christianson convincingly illustrates through various episodes and encounters, shaped a man who oscillated between rank arrogance and painful shyness, who craved intimacy while thrusting others from him, who attacked the work of others while resenting (or, rather, fearing) their criticism of his, and who insisted on the priority of his inventions while refusing to publish them. Christianson attempts no facile resolution of these polarities of behavior; rather, he makes them understandable, urging the reader's acceptance of the complexity of Newton's character, in part as a reflection of the complexity of the culture and of the times in which he lived.

Christianson is at his best in conveying the details and circumstances of Newton's life. His many vignettes of the people and events surrounding Newton are both interesting and entertaining, and they offer the reader a revealing sense of time and place. One feels oneself at times in the company of an accomplished tour guide who not only describes the layout of, say, Newton's Woolsthorpe house, or Trinity College, or London, but also fills those places with the people and events that gave them meaning. Christianson has the skilled writer's eye for the telling detail, be it a phrase from a document, an anecdote, or a forgotten custom, that pulls a scene together. Indeed, he does not hesitate every now and then to invoke the novelist's license to imagine what his subjects must have thought or felt at particularly dramatic moments.

Yet the wealth of detail, and the insight it offers, remain throughout the book external to Newton's science, revealing its context, not its content. Hence, the reader who already knows something of the science will find nothing new here, and the reader who is wholly unfamiliar with it will not learn much. Christianson speaks of Newton's mathematics but offers no substantive examples of it; one reads that Newton invented the calculus of fluxions, but one never encounters a fluxion. Christianson devotes a chapter to the circumstances of Newton's writing the *Principia* but sets forth from the work itself no more than statements of the three laws of motion. Though Christianson extols the power and elegance of Newton's demonstrations there, the reader never actually sees what one looked like. He speaks of how Newton's case for his celestial mechanics rested on the reconciliation of Kepler's laws of planetary motion with those of falling bodies on earth, yet the account of Book Three of the *Principia* skips over Newton's induction of universal gravitation from Kepler's third law and his demonstration that an inverse-square force acting on bodies close to the earth's surface yields Galileo's laws of fall. Even when such things are noted, they are not shown. The reader who does not understand them already will not learn them from Christianson. Only Newton's optics receives a treatment detailed enough to reveal both what Newton did and how he did it.

In the Presence of the Creator is a book for readers who, knowing the technical aspects of science in the late 17th century, wish to learn about its English setting. For that, Christianson offers a useful and readable synthesis of recent scholarship. For the science, one should turn elsewhere.

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Solar Eclipses

Total Eclipses of the Sun. J. B. ZIRKER. Van Nostrand Reinhold, New York, 1984. xii, 210 pp., illus. $22.50.

Laypersons who view a total eclipse of the sun are left with indelible impressions of one of nature's grandest spectacles. They may also remember those scientists who came from afar to carry out experiments.

So what are these experiments, how good are they, and, in point of fact, what has been learned from eclipse expeditions in recent years? This is the subject of Zirker's book. And such a treatment is long overdue; the last book on the subject was the somewhat anecdotal *Eclipses of the Sun* by S. A. Mitchell, the fifth edition of which was published in 1951.

Zirker is a solar physicist whose specialty is the chromosphere. But in *Total Eclipses of the Sun* his special interests are put aside and the discussion is far-ranging. Topics include astrometry (is the gravitational constant G temporally invariant?), solar physics (what heats the corona?), atmospheric physics (are global-scale gravity waves induced by the eclipse event?), relativity (what is the deflection angle of starlight as it passes close to the sun?), interplanetary dust (is the primordial solar nebula still with us?), and even biorhythms (do eclipses upset us?).

Our author has concentrated on experiments whose findings advanced our knowledge in significant ways. Of course eclipse observations may be but one approach, with space probes and outside eclipse studies supplementing, or even overwhelming, the eclipse technique—as for instance when radio interferometry proved more accurate than photography for the measurement of starlight deflection. Then there are experiments that fail because they are ill-conceived. Zirker gives those short shrift. Good experiments that give negative results get more attention.

Does the gravitational constant G vary with time as P. A. M. Dirac proposed in 1937, or is G time-invariant? Data on lunar acceleration can provide an answer. Acceleration of the moon's orbital motion occurs as a consequence of tidal friction. The value of lunar acceleration can be deduced from historic eclipse timings and from lunar laser ranging. The eclipse method depends on ephemeris time and involves G. The laser method depends on atomic clocks and is independent of G. According to P. Muller, the two measurements disagree and this discord can be taken as evidence for a change in G. At this juncture another decade of lunar ranging is needed to specify adequately $G(t)$.

Everyone knows that an early confirmation of Einstein's general theory was the observed deflection of starlight near the sun at eclipses. However, these photographic findings proved inadequate to distinguish between the predictions of Einstein and those of Brans and Dicke. In 1973 the century's longest eclipse took place in Africa, and a team from the University of Texas at Austin and Princeton University planned an unprecedented attack on the deflection question. An elaborate, temperature-controlled telescope was installed at Chinguetti, Mauritania. Unfortunately a vicious sandstorm reduced visibility at eclipse time to 18 percent of that expected. Even so, the team's findings proved the most accurate ever, giving the deflection at the sun's limb with 90 percent accuracy, but not good enough to distinguish between the two theories, for which better than 92 percent accuracy is needed. At this point radio astronomers took up the challenge and, by the use of microwave interferometry, confirmed Einstein with 99 percent accuracy. Presumably the eclipse technique is now outdated for this question.

What are the future prospects for eclipse observing? Certainly better work can often be done from spacecraft, which allow the measurement of those ultraviolet and x-ray wavelengths that are especially important to the chromosphere-corona regions. Nevertheless, there is a domain from the sun's surface out to one radius where the total eclipse remains supreme for the study of the corona. Diffraction from occulting disks and scattered light seriously limits coronal detection by space-borne coronagraphs. The cost of observing eclipses is a tenth, or less, that of spacecraft experiments, although clouds can escalate the cost:return ratio. There will always be opportunities for clever experimenters, and Zirker is optimistic that eclipse work will remain healthy.

Total Eclipses of the Sun is a succinctly written, up-to-date summary of the scientific return from the eclipse experience. The book is recommended for the advanced amateur and the professional astronomer.

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Planetary Atmospheres

Planets and Their Atmospheres. Origin and Evolution. JOHN S. LEWIS and RONALD G. PRINN. Academic Press, Orlando, Fla., 1984. x, 470 pp., illus. Paper, $29.50. International Geophysics Series, vol. 33.

Harold Urey single-handedly transformed the planetary sciences by injecting chemical insights into the arguments about the processes and boundary conditions occurring within the solar system, both present and past. Now, in an academic lineal descent, a "son" and a "grandson" have carried on his tradition with this important book about planetary atmospheres. The authors have based the book on their courses at MIT during