archetypes, as opposed to geometrical notions. Note that Pauli carefully recorded about 1000 of his dreams and that his depression on the breakup of his marriage did not affect his legendary powers of concentration. On his deathbed, Pauli named Jung as the one person he wanted to see.

While Enz's book is a monument of painstaking scholarship, its narrative does not flow well. It is constantly being interrupted by thumbnail sketches of people who crossed Pauli's path. The discussion of life in Zürich has so much detail that one needs a map to appreciate it. The space used up by such minutiae would have served better by including more Pauli anecdotes. Finally, much of Pauli's depth and wit, originally expressed in most elegant German, gets lost in the often stilted translations that are given.

Cohesion: A Scientific History of Intermolecular Forces

J. S. Rowlinson
Cambridge U. Press, New York, 2002. $90.00 (333 pp.).
ISBN 0-521-81008-6

Why does matter stick together? Why do gases condense to liquids, and liquids freeze to solids? *Cohesion* traces how those and kindred questions have been "tackled in the Western world in the last three hundred years." The book is an intricate and intriguing saga, ably presented by John Rowlinson, emeritus professor of physical and theoretical chemistry at Oxford University and a distinguished contributor to the analysis of intermolecular forces. His avowed "wider aim" is to exemplify the fitful development of a "branch of normal science," a field that did not endure Kuhnian revolutions but nonetheless is replete with periods of confusion, excitement, and stagnation.

The saga has many strands, some stretching back to antiquity. Rowlinson weaves a Brueghel-like tapestry that amply depicts both the tangled, contending notions about cohesive forces and the erratic, messy evolution of a science toward a coherent perspective. He portrays three broad periods of chaotic advances in chapters named after Isaac Newton, Pierre-Simon Laplace, and Johannes Diderik van der Waals.

In a final chapter, titled "Resolution," Rowlinson describes how quantum mechanics at last solved major conceptual puzzles, particularly about dispersion and retardation forces. However, he also shows that progress was significantly handicapped by an arrogant "reluctance to believe that anything of importance could have happened before the great days of quantum theory." He emphasizes as well that, despite the essential role of intermolecular forces in a host of current applications to biophysical dynamics and material sciences, there remain "fundamental limitations on our abilities to make accurate calculations, which no one yet knows how to overcome, and which few are willing to tackle."

The book admirably fulfills its stated aim of serving historians of science and also physicists or physical chemists curious about the roots of modern approaches to intermolecular forces. In its style and level of detail, *Cohesion* bears comparison with the epic story of intra-atomic and intranuclear forces given by Abraham Pais in his *Inward Bound* (Oxford U. Press, 1986). There is also apt contrast, in that *Cohesion* is much wider in historical scope; for the most part less technical; and, rather than celebrating abrupt paradigm shifts, chronicles a more gradual progress. Rowlinson's historical scholarship is extensive; he provides about 1200 notes and references, chiefly to primary printed sources, as well as a name index with 850 entries. For the 20th century, however, the huge expansion of pertinent work forces him to offer only impressionistic coverage of some selected topics.

Cohesion includes many episodes that are enhanced by historical context but deserving of wider attention as instructive or cautionary scientific parables. I note a few choice items. Newton envisaged matter as corpuscular and cohesion as due to short-range forces of attraction but refrained from publishing most of his speculations "lest I should be accounted an extravagant freak and so prejudice my readers against all those things which were [my] main design." Throughout the 18th century, metaphysical doubts about action at a distance in a vacuum and about elastic collisions of rigid spheres were great impediments. In the 19th century and beyond, ignoring such doubts became, as Rowlinson says, "one of the features of normal science."

More generally, Rowlinson illustrates "that scientists have a well-developed defensive mechanism when faced with theoretical obstacles. They ignore them, hope that what they are doing will turn out to be justified, and leave it to their deeper brethren or to their successors to resolve the difficulty." Indeed, the action-at-a-distance enigma was not resolved until the mid-20th century, when intermolecular forces were attributed to exchange of photons and consequently subject to the retardation effect. Rowlinson also demonstrates that scientists may be embarrassingly unaware of antecedent work. He notes, with regard to the hydrodynamic pressure tensor for a viscous fluid, that arguments advanced in the second half of the 20th century about its representation "duplicate, in ignorance, and almost word for word, some of those of a hundred years earlier."

Students of molecular science (and their teachers!) would do well to consult Rowlinson's book to see how discussions of topics such as capillarity, surface tension of liquids, elasticity of solids, and gas imperfection gain uncommon clarity from historical perspective, which brings out underlying assumptions and perplexing aspects often obscured in current texts. Those concerned about science literacy—either for the general public or for the coming generation of professionals—will find much material useful for seasoning their sermons.

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Order and Chaos in Dynamical Astronomy

George Contopoulos
Springer-Verlag, New York, 2002. $79.95 (624 pp.).
ISBN 3-540-43360-0

Imagine two black holes with just enough electric charge to cancel their mutual gravitational attraction. Then consider an uncharged test particle moving under the gravitational influence of those two fixed black holes and sharing a plane with them. In classical dynamics, the motion of the test particle turns out to be regular, but in general relativity it is chaotic.

Your reaction to *Order and Chaos in Dynamical Astronomy* will, I think, be much like your reaction to the two black holes. If you are charmed by the order–chaos dichotomy, you will find much to enjoy in the book. If it bothers you that nothing astronomers know of remotely resembles two fixed black holes, the book is probably not for you.

George Contopoulos has a half-century record of working on unusual but interesting problems. Best known for his work on high-order perturbation theory in stellar dynamics (the third integral), he also contributed—long before most others took any interest—