

Van der Waals Forces

A Handbook for Biologists, Chemists, Engineers, and Physicists

V. Adrian Parsegian

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Van der Waals forces—in competition with electrostatic interactions—are argu-

ably the most prevalent and relevant forces for understanding the properties of materials and living systems. Accordingly, research on these forces has enjoyed a long and rich history of funda-

mental physics contributions, and many expositions on their applications in chemistry, colloid science, and biology have been written. Adrian Parsegian's monograph *Van der Waals Forces: A Handbook for Biologists, Chemists, Engineers, and Physicists* is a highly original work that offers a welcome, stimulating, and useful addition to the literature.

The book succeeds in achieving two extremely ambitious goals. First, it sets out to demystify the classic theories from more than 60 years ago of Hendrik B. G. Casimir, Evgeny M. Lifshitz, and their coworkers in which dispersion interactions were first connected to the electromagnetic modes of continua. To that end, Parsegian discusses in detail the basic starting points and formal derivations underlying this statistical physics approach and its status relative to the earlier atomistic theories. Second, the book is intended as a how-to manual for biologists, chemists, engineers, and physicists. In this regard, a significant fraction of its 380 pages is devoted to a compilation and annotation of exact and approximate analytical results for dispersion interactions as explicit functions of the measured dielectric properties of real materials.

The book begins with the "Prelude," in which the long history and esthetic beauty of the subject are introduced. The reader learns about alternative approaches to dispersion interactions and begins to understand the respective strengths and limitations of those approaches and their reconciliations with one another. Chemists, biologists, and chemical engineers will be more famil-

iar with the classic long-range $1/r^6$ attraction between molecules in gases or colloidal particles in solution; physicists will be more familiar with the generic interactions between macroscopic objects arising from their perturbation of the electromagnetic spectrum of the intervening medium.

From the outset, the technical exposition is enriched by physical insights and clarifying, general remarks about the basic phenomena involved. For example, on page 20, in anticipation of the more systematic analyses that follow throughout the rest of the book, readers find the disarmingly simple statement, "A good rule of thumb is that interaction energies between two bodies in any geometry will be significant compared to kT as long as their separation is less than their size." Similarly, on the following page, readers are treated to a wonderful dimensional analysis of why a bug can't be too big if it wants to stick to the ceiling, and why it should have the right shape to do so.

The charming but substantive prelude is followed by "Level 1: Introduction." In this section, the essential ingredients of the modern theory of dispersion forces are presented, in particular the roles of imaginary frequencies in the electromagnetic spectrum, of zero-point energy, and of retardation effects. Of particular physical interest is the brief discussion of certain less familiar features of van der Waals forces, including repulsive interactions and torques between macroscopic bodies. An introduction to layered materials and the effects of spherical and cylindrical geometries is also presented.

The heart of the book, "Level 2: Practice," gives an account of how to calculate dispersion interactions from the general expressions of Lifshitz and others. The author gives tables of exact and approximate formulas for basic geometries and model systems—for example, for small and large separations, assuming no retardation; for small differences in permittivity; and so forth. At least as important as the tables are the accompanying essays on the tabulated formulas, which discuss the status of the various approximations involved, connections to the particle theory for gases and dilute suspensions (the Hamaker theory), the breakdown of pairwise additivity, generalizations to include ionic solution contributions, and the case of molecules and colloids interacting with substrates. This lengthy section ends with several extremely useful and edifying examples—including MathCad programs—of the actual computation of dispersion interac-

tions from both phenomenological models and measured spectra of the dielectric response for water and for particular hydrocarbons and metal systems of interest.

Just when readers are feeling good about having reached the end of the story, they are given an additional treat in the concluding section, "Level 3: Foundations." The author instructs readers in the mode summation approach of Nico van Kampen and colleagues by using it to derive general results of Lifshitz and coworkers and by working through the particular case of two semi-infinite media across a planar gap. He also shows how this fundamental theory can be generalized to multilayer systems, inhomogeneous media with spatially varying dielectric functions, and ion-containing anisotropic systems.

Throughout, the book contains several dozen problems of all kinds, with explicit solutions provided in an appendix, as well as a thoughtfully annotated bibliography of relevant primary and secondary sources. I can easily imagine *Van der Waals Forces* becoming an integral part of the personal libraries of the many types of scientists for whom it was written.

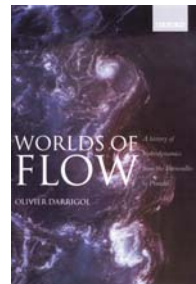
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Worlds of Flow

A History of Hydrodynamics from the Bernoullis to Prandtl

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Olivier Darrigol is a distinguished historian of science who had previously published a prize-winning volume, *Electrodynamics from Ampère to Einstein* (Oxford U. Press, 2000), on another branch of

physics. His latest book, *Worlds of Flow: A History of Hydrodynamics from the Bernoullis to Prandtl*, will be of most interest to historians, especially those who already have some knowledge of the scientists, engineers, and scientific topics that the author covers.

The text is very mathematical. Darrigol repeats the detailed derivations of the earlier mathematicians, including their sidetracks and mistakes, but with modern vector notation and methods.