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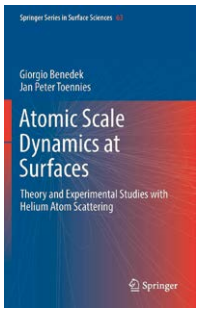

GIORGIO BENEDEK AND JAN PETER TOENNIES

ATOMIC SCALE DYNAMICS AT SURFACES
THEORY AND EXPERIMENTAL STUDIES
WITH HELIUM ATOM SCATTERING

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Mid of the Eighties in the last century, at about 2 a.m. in breezy night, I was getting out of the main building of what was named –at that time– the Max Planck Institute für Strömungforschung in Göttingen, while the counter of scattered He atoms from a (still) clean NaF (001) surface was accumulating events in a greenish histogram displayed on a old-style video of the pioneering Time of Flight HUGO II equipment, placed in the large laboratory hall. As a novice theorist working with Giorgio Benedek in Milano, I had the privilege of participating in a bit of the exciting history contained in the seminal book written by Jan Peter Toennies and him, that I am reviewing here. Yes, one of the key points emerging from *Atomic Scale Dynamics at Surfaces* is the long withstanding and daily collaboration, seldomly found in research stories, between experimentalists and theorists, resulting in a continuous interplay between interpretations, data, and predictions. Just as an example, whilst the measurements were running, the analysis of the scan curves and Rayleigh dispersion curves in the extended zone diagram was made by a team of theorists headed by Giorgio. This close connection is clearly found in the way the arguments are outlined in the 14 chapters of the book, a monumental work that took a quarter of a century, since 1994, to be completed by the authors, who have been the major players on the subject. It is just because of them being continuously involved in the never-ending developments of such a technique that the preparation took so many years, and the completeness of this volume resulting to be really exceptional, along with such a deep discussion of the effects, models and results that only scientists telling their own research could afford.

In reading this book, one has to keep in mind that three issues are fundamental in understanding the inelastic scattering of He atoms at surfaces, and they have to be analyzed in depth: the prediction of the surface vibrations, both as the breaking of the infinite periodicity in a solid and as the consequences of atomistic relaxations and reconstructions at the surface (chapters 3, 4 and 5); the interaction potential of the He atom with the surface and the scattering process (both single-phonon or multi-phonon in origin), in different approximations and for diverse materials (chapters 6, 7 and 8); the complex kinematics of the scattering experiments, including the notable case of bound state resonances, when the He atoms are temporarily trapped in surfing the surface profile (chapter 9 and 10). A very complete review of the nice agreement between theory and experiments is provided for insulators, semiconductors, metals, layered materials, non-ideal surfaces (chapter 11), and adsorbates or thin films (chapter 12): really, a hand-book *per se*. The volume is suitably complemented by the first two chapters on the introductory concepts and the history of this effect (from Rayleigh discovery to recent times), and by two closing chapters (13 and 14) on the next and far future of He atom scattering, including the multi-phonon processes and other interesting systems to be investigated. The key microscopic issue of such a technique, at variance with the complementary Electron Energy Loss Spectroscopy (also discussed in comparison, throughout this book) is that the He atom is gently hitting the surface charge density spilling out of the surface termination, and that such perturbation is very useful in understanding several phenomena, beyond the pure lattice vibrations.

The tone of the presentation throughout the chapters is never that of teaching something to someone else: it is more likely an open discussion between peers, so that the target reader is possibly an experienced PhD student, or a colleague. It was originated as a review paper, and it preserves such inclination even in a book as long as 600 pages, including a monumental collection of references and data. Beyond the significant value for the very subject, it is a great example of what scientific research is, actually a lesson in working epistemology, something not common in the present scientific communication. We really have to thank Peter and Giorgio for having written a book that is a guide to younger researchers, even devoted to other subjects: theory and experiments are working together, mutually understanding the critical issues, so that any detail is suitably addressed and, finally, understood. Total quality, in a Japanese mood of scientific production.

What can be added to such an excellent effort? Just an open question for the future of vibrational studies, beyond the He atom scattering technique: semiconductor nanomembranes and nanowires, some micrometers long and few tens of nanometers thick, still await a comparable method to assess the phonons populating these structures, eventually affecting their transport properties. Is this a new challenge for Peter and Giorgio epigones?

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