

BOOKSHELF

Space Radio Science by Oleg I Yakovlev, Taylor & Francis 2002, ISBN 0415273501, £60 (€94).

The twinkling of radio sources due to propagation effects is a nuisance most of the time, and radio astronomers try hard to remove these effects and sharpen up their radio maps. However, the scintillation can also be used in a positive way to probe conditions in the Earth's atmosphere and ionosphere, the interplanetary medium, the solar wind and the interstellar medium. For example, regular monitoring of the scintillations of extragalactic radio sources is now used to map out the interplanetary weather and the solar wind on a daily basis.

Artificial Earth satellites and deep-space probes have opened up even more elegant possibilities for remote sensing of planetary atmospheres and ionospheres and the solar wind. Satellites have many advantages compared with natural radio sources, as they are truly point-like and can transmit coherent monochromatic signals at several frequencies. Professor Yakovlev has devoted most of his scientific life to devising and interpreting such experiments. This extended monograph gathers together many of the insights he has gained, and provides a graduate-level introduction to this fascinating field of radio science. The book includes an extensive bibliography covering the period 1960–1999.

Chapter 1 starts with the basic physics of radio propagation through the Earth's atmosphere and ionosphere between ground stations and spacecraft, and ends with the topical subject of ionospheric tomography, in which satellite systems (such as GLONASS and GPS) transmitting coherently at several frequencies are observed simultaneously from different locations on the ground. This is a powerful tool for studying the ionosphere.

Professor Yakovlev's speciality, radio occultation studies, comes next. Reading between the lines I could glimpse the excitement of some of the early experiments. For example, the atmosphere of Venus is so thick that radio waves passing within 40 km of the surface are refracted by 6°, while waves that try to pass within 34 km of the surface of the planet suffer critical refraction and are captured. The radio occultation studies of the giant planets Jupiter, Saturn, Uranus and Neptune by the Pioneer and Voyager probes are outstanding achievements of space science in the 20th century. The same techniques have also been used to study the very rarefied plasmas around



smaller bodies, including Halley's Comet. Nearer to home, experiments between Mir and a geostationary satellite have demonstrated exciting possibilities for global monitoring of the Earth's atmosphere using satellite-to-satellite paths at several frequencies.

The core of the book covers radio sounding of the solar wind and the interplanetary plasma. By ingenious application of the techniques already expounded, Yakovlev explains how to measure the scale sizes and velocities of irregularities in the solar wind, the magnetic field, how to study magnetosonic and Alfvén waves, and much more. The book then changes direction slightly to deal with radar observations of planets, asteroids and comets, including detailed treatments of scattering from a rough surface, back scattering, effects of planetary rotation, bistatic radar experiments and sideways-looking synthetic-aperture radar. Finally there is a short, and to me disappointing, chapter covering basic principles for interstellar radio communications. This is fairly standard material, presented without the unique insights that make the rest of the book so much more interesting. Russian space probes have been monitored at Jodrell Bank since the early 1960s. Many of us wondered exactly what was going on up in Lab 5, and what became of the large number of data tapes forwarded to Russia. With the arrival of this book on my desk things have become clearer to me. I have enjoyed learning from an expert guide the joys of watching the signals twinkle and fade as

spacecraft pass behind a planet.

Jim Cohen, Jodrell Bank Observatory, University of Manchester.

High-Energy Particle Diffraction by Vincenzo Barone and Enrico Predazzi, Springer Verlag 2002, ISBN 3540421076, €74.95 plus local VAT.

Diffraction has played a fundamental role in physics for centuries, beginning with the realization of the wave nature of light. Given the wave-particle duality of quantum mechanics (QM), diffraction continued to be an important concept in non-relativistic QM scattering, and later in the study of elementary particle scattering using relativistic S-matrix theory.

For some decades after 1950, a vast experimental and theoretical effort went into the study of high-energy elastic and diffractive scattering of elementary particles, culminating in the largely unexpected discovery that cross-sections grow with energy. Being essentially non-perturbative processes, theory could not provide a really detailed description of elastic and diffractive scattering, but it did introduce a new idea that is truly fundamental. This new idea was the concept of complex angular momentum in non-relativistic QM (now a vital component in any serious book on QM) and its connection with the behaviour of relativistic scattering amplitudes at high energy. This led to the theory of Regge poles, which enjoyed enormous success in correlating the data on many reactions, though it also experienced some failures. Terms like Regge pole, pomeron and reggeon became household words. (A non-physicist spouse, upon being introduced to Tullio Regge at a party in the 1960s, is reported to have said: "Ah, Mr Pole, I have heard so much about you.")

The discovery of the partonic structure of hadrons and the advent of quantum chromodynamics (QCD) led to a dramatic change in the thrust of experimental high-energy physics, away from the study of elastic and diffractive scattering. Because of its property of asymptotic freedom, QCD was able to predict interesting correlations between experimental data in certain kinematical regions characterized by a hard scale. Consequently, a huge effort has gone into the study of such deep inelastic reactions.

But history, according to the Italian philosopher Vico, is supposed to be cyclical. So we should not be surprised to learn that there is a connection between certain aspects of

deep inelastic reactions and Regge concepts, and that the relatively new field of hard diffraction opens up the possibility of a bridge between Regge theory and QCD (leading, one hopes, to an understanding of Regge theory in the language of QCD).

Unfortunately, the concepts and language of Regge theory have largely fallen into disuse, so that several generations of young physicists, whose education had a lacuna in this field, now find themselves working on experiments in which such concepts are of importance. It is for these lost generations, and, of course, for the present generation of elementary particle physicists that this volume will be of great value. It manages to succinctly introduce all the important ideas in the Regge theory of diffraction (now referred to as soft diffraction) and attempts to connect these to the recent developments in hard diffraction and its interpretation in the framework of QCD.

There are three main sections to this book. The first offers a rapid but clear survey of scattering theory in both classical wave optics and non-relativistic QM. It also includes a discussion of the eikonal approximation, which plays a major role in later chapters, when attempting to understand the high-energy behaviour of very complex QCD Feynman diagrams. A chapter on relativistic kinematics introduces the concepts of rapidity and rapidity gaps, the latter being the current focus of intense experimental study in lepton-hadron deep inelastic scattering (DIS).

The second part of the book surveys concisely the old soft diffraction from the "golden age" of Regge theory. Here the emphasis is on those aspects of theory and experiment that are directly relevant to the present-day resurgence of interest in diffraction – i.e. to the diffractive aspects of hard interactions. The essential ideas of dispersion relations, Muller's generalization of the optical theorem to inclusive reactions and the key, rigorous theorems on permissible growth with energy of cross-sections are presented. Also discussed is the Pomeranchuk theorem relating particle-particle to particle-antiparticle asymptotic cross-section growth, but, surprisingly, no attention is drawn to the optics-diffraction motivation for the key assumption in the proof of this "theorem".

The reasons for introducing complex angular momentum, crucial in the development of Regge theory, are simply and convincingly explained, and there follows an intelligible

treatment of diffractive dissociation, the triple Regge limit (relevant to contemporary experiments), and how Regge theory can emerge from a field theoretic point of view. The latter is one of the most challenging issues in the study of perturbative QCD.

This section ends with a chapter devoted to the phenomenology of soft diffraction, summarizing cross-section growth, diffraction peaks and diffractive dissociation. The successful description of the energy behaviour of cross-sections in terms of Regge poles and the soft pomeron (that has an intercept of approximately 1.08) is emphasized. Included is a brief mention of the odderon, the intriguing object that seems to emerge from QCD and would be responsible for the breaking of the Pomeranchuk theorem, giving rise to a difference asymptotically between particle-particle and particle-antiparticle reactions.

The third section, about half of the book, is addressed to the relatively new subject of hard diffraction, which is currently under intense experimental study at DESY's HERA collider and Fermilab's Tevatron, and will be pursued at Brookhaven's RHIC and the LHC at CERN. This is a difficult subject. The theoretical approaches involve very complex and subtle calculations requiring the summation of an infinite series of Feynman graphs. The phenomenology is difficult to describe. The kinematic specification and experimental isolation of the class of events one wants to study is highly non-trivial and technically complex.

This final section begins with the theory of the BKFL equation, a perturbative treatment of generalized two-gluon exchange – summed to all orders in leading logarithmic approximation (LLA) – in parton-parton scattering. This leads to the conclusion that the gluon itself "reggeises", i.e. it behaves as a Regge pole and, perhaps more dramatically, that a pomeron-like object – the hard pomeron – emerges to control the high-energy behaviour of parton-parton scattering with an intercept of about 1.5. Perturbation theory breaks down in the range of small momentum transfer where the soft pomeron is operative, so it is not clear whether there is any incompatibility with the hard QCD pomeron. Unfortunately, studies going beyond the LLA appear to change the intercept appreciably and the full story remains untold.

After this challenging chapter we are offered a gentle introduction to lepton-hadron DIS and then led to the intriguing question of

the behaviour of the structure functions at very small Bjorken- x . Here the soft pomeron, the QCD hard pomeron and the small- x behaviour of the DGLAP evolution equations confront each other. The theoretical aspects seem, unavoidably, to be complicated.

The last two chapters are devoted to the new field of hard diffraction, first the phenomenological aspects, mainly in DIS, where the topology of rapidity gaps, the concept of diffractive structure functions and parton densities, and the partonic structure of the pomeron are explained. There is also a brief description of single and double diffraction in hadron-hadron collisions. In the final chapter the BFKL version of the hard pomeron and the colour dipole picture of a highly virtual photon are used to derive theoretical predictions for various hard diffractive reactions. Many processes of current interest are covered: jets in diffractive DIS, diffractive production of open charm and vector mesons, nuclear shadowing, colour transparency and the cross-section for $\gamma^* \gamma^*$ scattering.

High-Energy Particle Diffraction offers a comprehensive survey of the theoretical and experimental sides of one of the major areas of study in current elementary particle physics. It provides essential background information for younger physicists who were not taught about soft physics and Regge theory, and for those who were it is a helpful bridge to the newer area of hard diffraction. This book is not easy going. Some of the theoretical approaches are inherently very complex and, despite the efforts of the authors, remain an intellectual challenge. This is somewhat exacerbated by a large number of typographical errors, which will hopefully be rectified in the second edition. *Elliot Leader, Imperial College, University of London.*

Modern Cosmology edited by S Bonometto, V Gorino and U Moschella, IOP Publishing Ltd 2002, ISBN 0750308109, £75 (€118).

Cosmology has become a phenomenological science where large amounts of data from a host of precise experiments are being contrasted every day with concrete theoretical ideas about the early universe, based on general relativity and high-energy particle physics. Until recently, this happy situation was only envisioned as a dream in the minds of a few.

This book is a heterogeneous compilation of articles based on lectures, mostly from theorists, describing both the foundations and

the present status of cosmology. The lectures were given in the spring of 2000, at a doctoral school in Como, Italy. Unfortunately, as with any science in rapid progress, the book has become quickly outdated. Some of the authors, like Piero Rosati, still write the standard formulae of luminosity and angular diameter distances as a function of redshift assuming zero cosmological constant, two years after the discovery of the acceleration of the universe by the Supernova teams. Others, like Rita Bernabei (for dark-matter searches with the DAMA experiment) or GianLuigi Fogli (for neutrino masses and mixings) describe experimental results that are obsolete or outdated, given the great advances that these fields have made in the past two years (thanks to Edelweiss and the Sudbury Neutrino Observatory, respectively). The same applies to the chapter on galaxy clusters and large-scale structure (LSS), or the one on the anisotropies

of the cosmic microwave background (CMB), where the Sloan Digital Sky Survey and the Two Degree Field Galaxy Redshift Survey for LSS, and BOOMERANG, MAXIMA, CBI and VSA for CMB, have revolutionized their respective fields since the spring of 2000.

However, the reviews by John Peacock on the physics of cosmology, Arthur Kosowsky on the microwave background, Antonio Masiero on dark matter and particle physics, Philippe Jetzer on gravitational lensing and Andrei Linde on inflation, are very up to date and enlightening. They are a pleasure to read and may be extremely useful to PhD students and even researchers in other fields. The reviews of George Ellis on cosmological models, and Renata Kallosh on supergravity are somewhat technical and are probably beyond the level of doctorate students. On the other hand, I miss some discussion on gravitational waves, the Sunyaev-Zeldovich effect and perhaps even

ultra-high-energy cosmic rays.

In summary, I think the book is a nice compilation of the status of cosmology in the year 2000. It gives the right perspective of what is to come in the next few years, or even decades, with inflationary cosmology as the early universe paradigm at the heart of a standard cosmological model, connecting astrophysics with high-energy particle physics. *Juan Garcia-Bellido, CERN.*

Books received

The Theory of Open Quantum Systems by H P Breuer and F Petruccione, Oxford University Press, ISBN 0198520638, £55.00 (€86).

Finite Element and Boundary Element Applications in Quantum Mechanics by L Ramadas Ram-Mohan, Oxford University Press, ISBN 0198525222, £24.95 (€39).

LETTERS

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Summer students

As an old CERN friend and alumnus I have much enjoyed the recent articles in *CERN Courier*, by Gordon Fraser and others, looking back on CERN's early years. In the July/August issue (p8) you very appropriately reminded readers of the beginnings of the Summer Student Programme, which was conceived with great foresight by the administration of the early 1960s.

However, I don't think it is quite correct to credit the origin of the programme to Victor Weisskopf's directorship. If I am not mistaken, the programme started in a modest fashion as early as 1960, when information was spread in member state institutions that advanced students could apply for a 6-8 week stay at CERN, with travel and a modest subsistence

paid by the laboratory. I myself was lucky enough to be accepted as a summer student the following year, after having been encouraged by my professor, Alexis C Pappas, in Oslo to apply. One of the events I remember most vividly from that summer of 1961 was the gathering of staff and visitors outside the steps of CERN's main building in early August when Viki, on crutches, took over as CERN director-general from a young John Adams.

As I recall there was no organized lecture programme for summer students in 1961, but we had ample opportunity to attend seminars and conferences taking place at CERN. I was attached to the nuclear chemistry group, where my task was to adapt a novel technique for preparing thin samples for absolute beta-counting. It is quite remarkable and pleasing for an old member that this group, some years later renamed ISOLDE and still residing in the same old offices, has maintained its world leadership in the study of short-lived radioac-

tive nuclei to this day.

Although I cannot claim comparison with the distinguished physicists mentioned in your article, it is certainly true for me that the short stay as a summer student in 1961 staked out the path of a future career where CERN has always played an important role. After pursuing work in nuclear chemistry and physics in Norway, Denmark and Sweden, I returned to CERN as a staff member in 1969 in the ISOLDE group until 1976, followed by a period as corresponding fellow for another three years. A few years later, after having moved on to a new career in research administration at home, I became heavily involved with CERN again as a member of the Norwegian delegation to the finance committee and Council.

I congratulate the CERN Summer Student Programme on its first 42 years and convey my best wishes for an equally successful future. *Leif Westgaard, Norwegian delegate to CERN Council.*

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