years has devoted himself to infrared instrumentation. As a result (one assumes), many of his references are from before 1976, rendering the book half a decade out of date in a field barely thrice that old. Although it bears a 1980 copyright, for example, the book excludes all of the major advances achieved with the Einstein telescope; the only mention of the Observatory is a useless and repetitive "prediction" that significant new results will be forthcoming.

Who the book's intended audience is, is obscure. Adams spends time explaining concepts like luminosity and flux but assumes complete familiarity with the eccentric nomenclature of stellar spectral classification. One of the six chapters is devoted exclusively to a development of the basic equations for various astrophysically important radiation processes, but the following discussion of individual x-ray sources and source classes is rather vague and qualitative. The cover flap suggests the book is for undergraduate students and amateur astronomers; I found the style (turgid), level of detail (uneven), and approach unsuitable for either group, although the book might conceivably be useful as a secondary reference for an advanced undergraduate course in observational astrophysics.

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THE BETTMANN ARCHIVE, INC.

Gay-Lussac, Scientist and Bourgeois

M. Crosland
333 pp. Cambridge U. P., New York, 1979. $36.00

In this new biography, Maurice Crosland rescues the discoverer of Gay-Lussac's law and the inventor of the Gay-Lussac tower from obscure eponymity. Joseph-Louis Gay-Lussac (1778–1850) is revealed to be an industrious and skilled but cautious investigator, whose research ideal was to uncover the quantitative relationships governing physico-chemical phenomena and whose mature interests turned increasingly toward applied science.

Crosland also locates him in his time and place—the first half of the nineteenth century in France—when science could be made the basis of a new kind of middle-class professional career. In this regard Gay-Lussac was certainly a successful prototype. He achieved scientific renown and a highly rewarded career. He attained key positions in the French scientific establishment: membership in the First Class of the Institute (1806); a professorship in the Paris Faculty of Sciences (1809); and a chair at the *Ecole Polytechnique* (1810). Crosland shows how Gay-Lussac acquired and exploited these positions in building his career and demonstrates effectively how the various stages in the construction of the career influenced Gay-Lussac's scientific interests.

The educational reforms of the Revolution made possible the training necessary for such a life in science. Young Joseph-Louis, son of a provincial lawyer whose circumstances had been much reduced by the political cataclysm, came to Paris in 1795 to complete his schooling and prepare for a profession. Probably he intended to follow his father into the law. Away from parental supervision he was seduced by mathematics and entered the recently founded *Ecole Polytechnique* in 1797. The original aim of this famous school, which has played a large role in the training of the French bureaucratic elite, was to provide a general scientific education preparatory to entry into one of the "applied" schools such as the Artillery School, the School of Mines and the School of Bridges and Highways. The curriculum was dominated by mathematics, mechanics, chemistry and engineering drawing. Although Gay-Lussac seemed destined for a career in civil engineering and was in fact enrolled at the School of Bridges and Highways for about a year, he had been spotted in his last year at the *Polytechnique* by the great French chemist Claude-Louis Berthollet, who admitted the young *polytechnicien* to his household and laboratories and guided his transition from science student to scientific researcher. The main site of this transformation was Berthollet's country house at Arcueil on the outskirts of Paris. At Arcueil, too, France's greatest mathematical astronomer and physicist, Laplace, had his suburban retreat. Here the two pre-eminent scientific figures of Napoleonic France gathered around them a coterie of young scientists whose research they fostered in their laboratories and whose careers they sponsored in the halls of the Parisian scientific establishment. The group, called the Society of Arcueil (the subject of a previous book by Crosland), was actually a private research school that provided the facilities and support that we now associate with graduate training. The importance of Gay-Lussac's association with the Arcueil circle can be seen both in his research productivity and in his success in reaching key positions.

The influence of Arcueil also reached down into the content and style of Gay-Lussac's science. Not surprisingly, given the interests of the leading luminaries, the boundaries between physics and chemistry at Arcueil were indistinct. It is noteworthy that Gay-Lussac's research in this period included work on the thermal expansion of gases (he was the first to publish the relationship now known as Charles's law), on the earth's magnetic field, and on capillary attraction, as well as on more conventional chemical topics.

For the patronage of Arcueil, however, Gay-Lussac paid with a loss of scientific independence and originality. He was never able to claim full significance for or to exploit the law of combining volumes in terms of the new chemical atomism propounded by Dalton, since his mentor Berthollet was a resolute opponent of the law of fixed proportions, which was the basis of Daltonian atomism. Likewise the conclusions drawn from his excellent work with Thenard on the gas that Humphrey Davy named chlorine were hedged in by Berthollet's continuing loyalty to Lavoisier's oxygen theory of acids.

As Gay-Lussac emerged in the teens and twenties as an authority in his own right, the influence of Arcueil receded (although the loyalty never diminished), and his work became more exclusively chemical. He also became a scientific expert, writing official memoirs and instructions to advise the government and industry on technical matters. He was appointed Assay Master at the Paris Mint in 1829, a post which virtually doubled his income. In the 1830s and 40s came his lucrative association with the Saint-Gobain chemical works, to which he sold the patent on the Gay-Lussac tower for a considerable sum of money. Gay-Lussac's scientific career thus became linked to the nascent industrial world of the nineteenth century. When he entered politics in the 30s as a member of the Chamber of Deputies, he was a spokesman for business interests. His outspoken views on the evils of government regulation of industry would

have made him a hero in the present Washington administration.

While Crosland's biography is more the map of a career than a portrait of a man, one senses no great loss here. Gay-Lussac, it seems, was not a striking or interesting personality. However, his life is revealing for what it teaches us about how scientists became accepted and important figures in the modern industrial world. This is a story Crosland has told well, drawing on his extensive knowledge of French science in this period. It is recommended to those who have followed Gay-Lussac into the career of science and who would like to understand something of the historical forces that have shaped their own lives and values.

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The Physics of the Interstellar Medium

J. E. Dyson, D. A. Williams
206 pp. Halsted (Wiley, New York), 1980

The interstellar medium contains a diverse array of physical environments varying from a hot highly ionized component at a temperature of 300 000 K and a density of 0.003 cm^{-3} to cold molecular clouds at 10 K at densities exceeding 10^4 cm^{-3}. Where the massive stars end their lives the interstellar medium is in a chaotic and violent state. There supernova explosions enrich the interstellar gas with the heavy elements produced by nuclear burning in the star, generate energetic cosmic rays and drive shock waves into the medium. These processes create the conditions in which gravitational collapse and cloud fragmentation may occur and a new generation of stars may arise. The formation of stars is accompanied by mass loss in the form of stellar winds and by expanding ionization zones that interact dynamically with the surrounding gas and dissipate the remnant material out of which the stars are made.

Much of the activity in hidden from visual observation because of absorption by solid dust particles; accordingly, the entire electromagnetic spectrum from the long wavelength radio region to the hard x-ray region is used to explore the extraordinary variety of interstellar phenomena.

The interpretation of the observations and the development of a unified description of the interstellar medium demands an understanding of a broad range of physical and dynamical processes. The interstellar medium in turn provides a stimulating arena in which to learn about the physics and chemistry of complex situations of a kind that cannot be simplified by limiting the number of variables but can only be understood by enlarging the observational base.

This book, by John E. Dyson and David A. Williams, uses the interstellar medium as a vehicle for discussing an extensive body of physical and dynamical processes, at an introductory level that should make it readily accessible to most undergraduate seniors in the physical sciences. The authors are expert guides to the subject: Williams, particularly in atomic, molecular and grain processes, and Dyson, particularly in fluid mechanics and dynamical processes. Both have made important original contributions. The book, written in a straightforward style, provides explanations that are lucid and concise. Dyson and Williams give a general account of the structure of the interstellar medium and the observational methods used to probe it. They describe the gas-phase and grain-surface processes occurring in the determination of the ionization and thermal balance and in the formation and destruction of molecules, and they present order-of-magnitude estimates of the temperatures, the degree of ionization and the densities of the various phases of the interstellar gas. The subject of gas dynamics is introduced with a discussion of first principles and moves rapidly but intelligibly to a discussion of shock waves and the effects in interstellar space of expanding nebulae, stellar winds and supernova explosions.

In summary, the book is an excellent introduction to the physics of the interstellar medium. It manages in 200 pages to address most of the important questions and to provide an interesting exposition of the unusual combination of physical, chemical and dynamical principles that are involved in interpreting interstellar phenomena.

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Theory and Applications of Electron Spin Resonance

W. Gordy
625 pp. Wiley, New York, 1980. $39.95

Spin Exchange: Principles and Applications in Chemistry and Biology

Yu. Molin, K. Salikhov, K. Zamaraev
242 pp. Springer, Heidelberg, 1980. $39.00

In 1980 there were 2550 entries in *Chemical Abstracts* under the category "electron spin resonance," up from 2100 in 1975 and 1600 in 1970. These entries seem almost equally divided among chemistry, biology and physics and between applications in the solid and the liquid phases (few are in the gas phase). Electron spin resonance spectroscopy is a tool that has been applied in almost every area of science that is concerned with the electronic structure of matter. This feature of the field—an enormous range of applications linked together by a common technology—creates problems for readers and authors alike. For example, Walter Gordy's book dismisses the subject of spin exchange in liquids in two sentences, while Yuri N. Molin, Kev M. Salikhov and Kirill I. Zamaraev devote their entire monograph to the subject. Every author of an esr book must somehow limit the range of subject matter, and few readers will be completely happy with the choices that are made.

Theory and Applications of Electron Spin Resonance contains four chapters on general esr theory and background; the remainder combine applications and theory in several major branches of esr spectroscopy. No space is devoted to apparatus or experimental details. Spin-labeling, transition metals, double resonance and pulse techniques are also omitted.

The theoretical chapters are suitable for an introductory esr course at a first-year graduate student level. The material could also be used to illustrate various principles in a course on quantum chemistry. While these chapters are straightforward and sound, there are omissions. No mention, for example, is made of Alfred G. Redfield's contributions in the chapter on line strengths, line shapes and relaxation phenomena. Nor is there any discussion of Jack H. Freed's work on relaxation in the liquid phase.

Many of the chapters rely to a heavy degree on work done by Gordy, one of the handful of outstanding scientists who recognized the intrinsic importance of esr spectroscopy just after World War II and helped to lay its foundations.

There are numerous important subjects in esr that are elegantly reviewed: for example, matrix isolation of small molecular free radicals and nuclear couplings in oriented free radicals, the discussion of which includes C^{13} and N^{14} couplings and couplings of α and β protons to both C and N. I found that the section on coupling of protons bonded to nitrogen gave a very useful perspective to a problem in my own research. I suspect that professionals in the field will use this book in just such a manner.

In short, what can be found in Gordy's book is fine. If something isn't there, it is an unfortunate and an inevitable consequence of the mismatch between author and reader in this complex field.

Spin Exchange: Principles and Ap-