20th-century cosmology

DER NEUE KOSMOS. By Albrecht Unsöld. 356 pp. Springer-Verlag, Berlin 1967. Paper $4.50

by R. Bruce Lindsay

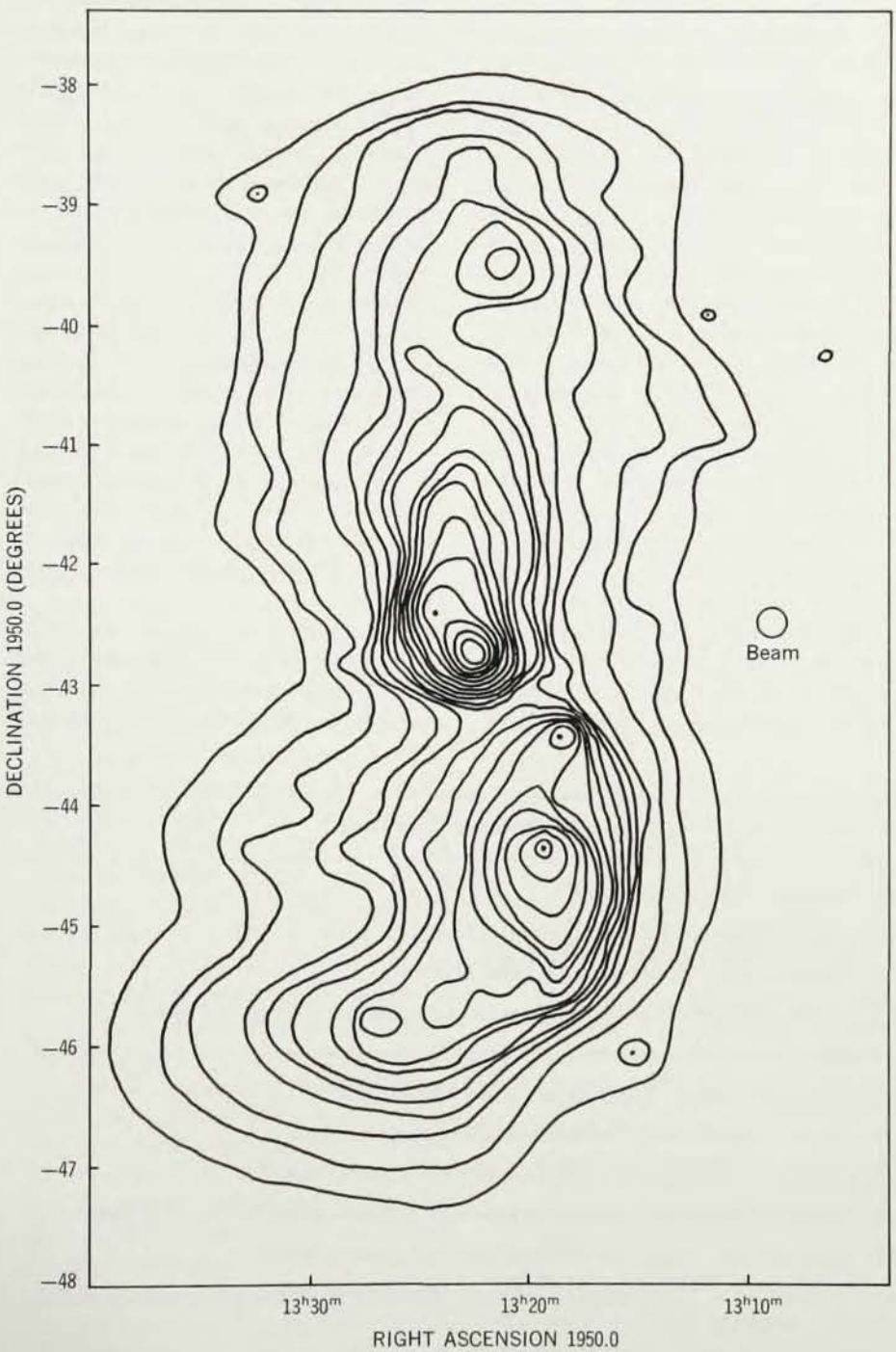
Astronomy is in many aspects the most fascinating of the physical sciences. Its observational material refers to those elements of our experience most extensive in space and time, while its theories employ all the apparatus of the most sophisticated branches of theoretical physics. We listen with awe to what the astronomers say they learn with their impressive optical and radio telescopes, and with equal wonder to the stories of the theoretical astrophysicists as they tell us what is really going on "out there" and what is the meaning of it all.

Albrecht Unsöld, quantum physicist and astrophysicist, is director of the observatory at the University of Kiel. His book is also aimed at a wide range of readers, though with the assumption that they possess a substantial background of mathematics and physics. In his preface Unsöld recalls to our attention the great 19th-century scientific classic *Kosmos* of Alexander von Humboldt who aspired to give a meaningful view of the universe to the educated reader. Unsöld's work aims to tell the story of the new cosmology that has been constructed during the 20th century.

Within the framework of a relatively small volume the author has achieved his purpose remarkably well. By an ingenious combination of history, descriptive astronomy and modern astrophysics, he has been able to make the reader appreciate the most recent theories of the structure and possible fate of the universe.

The book is divided into three parts. The first section, referred to as classical astronomy, is devoted principally to descriptive and dynamic astronomy, with emphasis on observational techniques and results and on the solar system. The second part discusses the sun and stars and provides an introduction to astrophysics with a discussion of the constitution of the stars. The third part covers star systems, the development and decay of stars and the overall behavior of galaxies. The last section then concludes with a relatively simple explanation of the application of relativity to cosmology.

To compress such a large amount of material into such a small compass the author has had to adopt a rather compact style. I cannot pretend that the book reads like a novel; nevertheless the style is clear and the emphasis on history is particularly attractive. The book has a helpful bibliography



RADIO SOURCE Centaurus A, identified as NGC 5128, observed at 21-cm wavelength by B. F. C. Cooper, R. M. Price and D. J. Cole. Contour lines show temperature increasing from 0.25 K at edges to over 215 K at center. (From *Der neue Kosmos*)

and a detailed index, both of which greatly increase its value as a work of reference.

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The reviewer is Hazard Professor of Physics at Brown University.

Singular eigenfunctions

LINEAR TRANSPORT THEORY. By Kenneth M. Case, Paul F. Zweifel. 342 pp. Addison-Wesley, Reading, Mass., 1967. $17.50

by G. C. Pomraning

The application of singular eigenfunction methods (theory of distributions) to transport problems was first discussed in 1955 by N. G. Van Kampen in an investigation of plasma oscillations. Five years later the first author of the present book introduced the method into neutron-transport theory. Since that time, Kenneth Case and Paul Zweifel, together with their colleagues and students at the University of Michigan, have contributed significantly to the further development of the use of this elegant mathematical technique in transport problems. *Linear Transport Theory* is the first comprehensive treatment of this subject which heretofore was widely scattered throughout the literature. Although the book is not limited to an exposition of this technique, it clearly was the motivation for its being written.

The first three chapters contain introductory material. Following an intuitive derivation of the neutron transport equation in chapter 1, the next chapter discusses general properties of the equation, including uniqueness, boundary conditions, Green's functions, and the reciprocity theorem. Chapter 3 gives a discussion of the neutron-transport equation in the absence of regeneration (pure-absorber problem) for which a simple, complete solution is easily found. Chapters 4 through 7 form the heart of the book. It is here that the method of singular-eigenfunction expansions is introduced and applied to several transport problems in the neutron-diffusion context. The question of the orthogonality and completeness of the eigenfunctions over various angular domains is treated rather extensively, as it should be. Applications are given to steady-state problems in both infinite and half-space situations, time-dependent problems, and the slab criticality and albedo problems. Chapters 8 and 9 introduce the reader to other methods of solution of the neutron-transport equation, including the spherical-harmonic (P-N) discrete-ordinate (in particular, Gauss quadrature), straight-line (S-N) and invariant-imbedding techniques. The book ends with a chapter on the application of linear-transport theory to areas of physics other than neutron diffusion, such as gas dynamics, plasma physics and radiative transfer.

The method of singular eigenfunctions stems from the observation that the homogeneous-transport equation describing one-speed steady-state neutron diffusion in a uniform planar medium admits a solution that is separable in space and angle. The spatial dependence is exponential with the e-folding distance called the "eigenvalue" and the angular dependence called the "eigenfunction." If one allows only well behaved solutions, one finds, in the simplest case of isotropic scattering, only two eigenvalues, corresponding to the asymptotic angular distributions. However, if one also allows singular eigenfunctions, involving Dirac delta functions, a continuum of eigenvalues results. The two discrete modes together with the continuum are shown by Case and Zweifel to form a set of eigenfunctions complete enough to describe the solution to certain transport problems. The singularities in the continuum modes do not appear in the solution to a given problem since an integration over these eigenfunctions is always performed.

Through chapter 7 the book is very well done. The introductory material is clear and concise. The exposition of the singular-eigenfunction-expansion method shows the authors' expertise in this area and is presented in just the right amount of detail for this reviewer. Unfortunately, the discussion of the P-N, S-N, and discrete-ordinate methods is not of the same caliber. This chapter contains several misleading statements and errors. For example, the claim is made that the spherical-harmonic technique is equivalent to the Gauss quadrature method. This is only true in one-dimensional geometries. Also, the S-N method described by the authors has been obsolete in practice for almost a decade. The discrete-ordinate technique that they discuss has superseded the straight-line S-N method and, in fact, is now referred to as the S-N method. An unexcelled example of poor proofreading is found in the discussion of the diffusion-theory solution of the critical slab problem. The diffusion equation is wrong, the boundary condition is ambiguously stated, and the resulting criticality equation is neither the proper solution to the incorrect diffusion equation or to the correct diffusion equation. The last two chapters of the book on invariant imbedding and the use of linear-transport theory in other areas of physics are very brief and serve only to whet the appetite of the reader. Presumably this was the intention of the authors.

It is worth pointing out that this

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