ASTRONOMIE, COSMOLOGIE

ARTHUR STANLEY EDDINGTON: *The Internal Constitution of the Stars*. Cambridge: Cambridge University Press, 1988 (1st Edition 1926, reissued in the Cambridge Classic Series, with a new foreword by S. Chandrasekhar.) xiv, 407 pp., figures, tables and index.

In Eddington's by now classic account of astrophysics inside the stars many pure disciplines such as quantum theory, thermodynamics and relativity theory left their imprints. Since the book was written between May 1924 and November 1925, Eddington could not integrate ideas stemming from the just emerging new quantum mechanics of Heisenberg *et al.*, but in some cases he anticipated contributions to problems left open in his treatment [1].

In spite of the transitional character of details in Eddington's treatment, it soon became a classic textbook for all students in the field, because there are many substantial contributions made by Eddington surviving all subsequent theoretical and observational progress:

– Eddington pioneered the systematic survey of possible mechanisms of "subatomic energy" supply as the source of stellar energy (chapter XI), thereby breaking with the traditional speculations about meteoric impact and the contraction hypotheses of Helmholtz and Kelvin. Although the fundamental idea of conversion of mass into energy *via* Einstein's energy-mass-equivalence and its possible application to the fusion of four H-atoms to one Helium-atom with a mass defect of about one percent was clear to him, the details of the formation of helium out of repelling constituents at that time had to remain "mysterious" (p. 301, compare p. x) and Eddington openly confessed that "a critic might count up a large number of 'fatal' objections" (p. 25). Also, he thought about radioactive decay and mutual cancellation of electron and proton as alternative mechanisms of internal energy supply, "airy speculations" only when judged from today's perspective.

– He consistently operated with radiation-pressure as counterforce to gravitation (15ff.), thereby implementing results by Hasenöhrl (1904, 1909), Lewis (1908f.) and of course Einstein (1906) about momentum and inertia associated with light waves. But the so far extremely minute effects of radiation testable only in precision experiments of torsional balance of reflectors under focus in earlier studies 'magnified', transformed into intense pressure of outward flowing radiation comparable "to a wind blowing through the star and helping to distend it against gravity" (p. 15).

– He broke with the usual preference of convection currents as the modus of heat transfer from the center of the star to its surface and argued for heat transfer by radiation as the only realistic possibility (pp. 5,9,98), relying on pioneer studies by Sampson (1894) and Schwarzschild (1906) about the sun, but extending these to stars with different physical conditions.

– Other astrophysical theories and hypotheses such as *e.g.* Emden's treatment of polytropic gas spheres (1907), Hertzsprung and Russell's 'giant and dwarf theory' (1913) or the mass-luminosity law (1924) were either improved or criticised if necessary (7, 79ff., 163ff.) with the aim of giving a unified account of all available knowledge about stars.

– Eddington was one of Britain's leading experts in general relativity [2], but unfortunately most of

[1] *E.g.* the calculation of the coefficient of opacity (21f., 249) or the "reason why an atom behaves like a rigid body of definite size" (p. 165), later explained with the aid of the Pauli-principle, quantum statistics and nuclear force models.

[2] See S. Chandrasekhar, *Eddington: the Most Distinguished Astrophysicist of his Time*, Cambridge Univ. Press, 1983, for an overall account of his contributions to physics.

the problems discussed in this textbook were outside the realm of relativistic treatment. Only occasionally he touched possible relativistic themes such as experimental verifications of the gravitational redshift (p. 173) or the relativistic implications about systems of condensed mass catching light rays (p. 6), first inaugurated in Laplace's famous vision and only much later studied under the label 'black hole'. In spite of his relativistic preoccupations, Eddington frequently used the concept of aether, but only as a means of illustration *per analogiam* (see *e.g.* 10, 18f., 103).

- Finally, he also reflected on the epistemological status of a theory dealing with nonobservable entities like the interior of a star and methodological peculiarities of astrophysics in contrast to physics and mathematics (56, 101, 296, 300).

The best recommendation might perhaps be an extract out of Eddington's "knockabout-comedy of atomic physics" (p. 19f.), exemplifying his superb talent as writer of informative *and* entertaining textbooks; others would cite his witty remarks about thermodynamic problems with highly condensed matter of white dwarfs in a paradoxical, Carrollian fashion (p. 172). Still others, like Chandrasekhar in his condensed new foreword written for the reprint (p. viii), have praised an amazing thought experiment (p. 16) operating with a physicist on a cloud-bound planet who gets his clues by simple combination of natural constants and stellar magnitudes, foreshadowing Eddington's later preoccupations with dimensionless constants in his *fundamental theory*. But in my opinion, it is Eddington's visionary insight into *open* problems and his frank acknowledgment of challenging anomalies, not so much his detailed treatment of well-understood aspects of astrophysics, that are most interesting for today's readers. Those who are informed about the later progress in the subject [3] will certainly enjoy to share Eddington's impression of being "in the interesting state when we cannot help feeling that we are not far off the right track and the true solution is waiting just round the corner" (p. 24). More information on later developments in the foreword would have helped the non-expert to appreciate Eddington's efforts to overcome the "confused state" (p. 8) of stellar theory in his times.

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