FROM BLACK CLOUDS TO BLACK HOLES

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From Black Clouds to Black Holes

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*Twinkle, twinkle, little star,
How I wonder what you are;
Up above the world, so high,
Like a diamond in the sky.*

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Preface

Man's age-old curiosity about the heavens has found expression in a variety of ways ranging from poetic fancies to profound philosophical thoughts and deep-seated religious beliefs. Science entered into the picture comparatively recently, but it has done so with commendable success.

Indeed, it seems audacious even to attempt an application of the scientific laws, discovered under very limited conditions here on the Earth, to heavenly bodies that lie light years away and even beyond. Unlike his counterpart in other branches of science who can handle or tamper with the systems under his study, the astrophysicist is forced to watch them helplessly from great distances. It is therefore all the more creditable that he should have achieved any measure of success at all. One can go even further and assert that astronomy has provided fresh inputs into our understanding of the physical world that would not otherwise have come at all. For example, but for the astronomical observations of the planets and satellites, the law of gravitation (which is one of the four fundamental laws of physics) would have long remained undiscovered.

No branch of astrophysics can claim as impressive a record of successes as the study of the internal constitution of stars and of how stars evolve with time. Long before laboratory physicists could even think of nuclear fusion as a source of energy, the astrophysicists had stellar models which worked on this process. It is through the study of stellar evolution that we receive a clue to the origin of the variety of different chemical elements found in the Universe. Even such esoteric objects as black holes have a natural place in the life story of stars.

The aim of this small book is to tell that story in as nontechnical

a language as possible, and to convey to the lay reader the excitement that drives the astrophysicist to even more ambitious tasks that lie ahead. For example, the mystery of how the galaxies consisting of hundreds of billions of stars came into existence, the riddle as to what source of energy powers the highly luminous but highly compact quasars, and of course the most fundamental question of the origin of the Universe as a whole constitute some of the challenging fields in astronomy. It is because of his ability to understand what is going on inside stars that the astronomer feels confident today that these questions also will receive at least partial answers in the not-too-distant future.

The first four chapters in the book prepare the groundwork for the stellar odyssey. The story of a star's life begins in Chapter 5, in the visually dark interstellar clouds. It ends in Chapter 10, when a star unwise enough to retain too much weight late in its life ends in a black hole. The intervening chapters describe how the changing physical characteristics of a star can be explained with the physics that we know here and now. But, as outlined in the final chapter of the book, there are still some mysteries left even in this relatively well understood part of astrophysics.

While attempts have been made to keep the description as non-technical as possible, a few simple formulae could not be avoided. Likewise, occasional use of powers of ten and the logarithmic notation had to be made: it is hoped that the uninitiated may find the Appendix at the end helpful in this context.

The book owes its origin to an invitation from Professor K.K. Phua to write for the World Scientific Publishing Company, and I am grateful to him for his help and encouragement. The preparation of illustrations was greatly simplified with the help of the drawing and photography sections of the Tata Institute of Fundamental Research. Finally, it is a pleasure to thank Mr. D.B. Sawant for fast and efficient typing of the manuscript.

Bombay, India

Jayant Narlikar

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