A SHORT BIOGRAPHY
OF
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(ssk @ galileoinstitute.org)

Dr. Shiv S. Kumar was born on March 15, 1939 in Bannu, India (now Pakistan). After obtaining a BSc (Honours) degree in Mathematics from Lucknow University (Lucknow, India) in 1957, he joined the University of Michigan (Ann Arbor, Michigan) as a graduate student/research assistant in the Department of Astronomy. He obtained a PhD degree in Astronomy from Michigan on February 3, 1962. His PhD dissertation dealt with the theory of non-grey stellar atmospheres.

In addition to the University of Michigan, he has worked at the following institutions: Smithsonian Astrophysical Observatory, Cambridge, Massachusetts (1960-1961); Goddard Institute for Space Studies, New York City, New York (1962-1963); Physical Research Laboratory, Ahmedabad, India (1963-1965); University of Virginia, Charlottesville, Virginia (1965-1998); Australian National University, Canberra, Australia (1970-1971). Currently he is president of The Galileo Institute, Ruckersville, Virginia, and emeritus faculty member at the University of Virginia. The Galileo Institute, an independent institution for scientific research and education, was founded by Dr. Kumar in 2000.

Since 1957, Dr. Kumar has worked on the problems of the origin and evolution of stars of very low mass, the origin of the Solar System, star and planet formation processes, the theory of stellar atmospheres, the origin and evolution of life in the universe, and other problems. Most, but not all, of his scientific contributions during the period of 1957-1974 are summarized below:

THE THEORY OF STARS OF VERY LOW MASS (1958-1962)

During the period 1958-1962, Dr. Kumar developed the theory of stars of very low mass ($M<0.1 M_{sun}$) which led to several important predictions concerning the structure and evolution of these objects (1,2,3,4). The theoretical predictions, which have mostly been confirmed by subsequent theoretical work and/or observational studies, are briefly discussed below:

1. The first computation of the minimum hydrogen-burning mass limit was completed by Dr. Kumar in the summer of 1962 when he was working as a NAS-NRC Postdoctoral Research Associate at the Goddard Institute for Space Studies (New York, New York). The numerical value of this critical mass varies with chemical composition and his computations led to the currently accepted values of -0.07 Msun for Population I stars and -0.09 Msun for Populations II stars. These limits also define the bottom of the hydrogen burning main sequence in the H-R diagram for the two stellar populations. The hydrogen burning mass limit has been referred to as the Kumar limit by some scientists (5, 6, 7, 8).
2. The structure and evolution of stars with mass below the H-burning limit was studied by Dr. Kumar during 1958-1962 while working at the University of Michigan, Ann Arbor, Michigan (1958-1960), Smithsonian Astrophysical Observatory, Cambridge, Massachusetts (1960-1961) and NASA's Goddard Institute for Space Studies, New York,

New York (1962). The main prediction of the theoretical calculations was that the H-rich stars with mass below the H-burning limit become completely degenerate objects without ever going through hydrogen-burning thermonuclear reactions. Dr. Kumar referred to these completely degenerate objects as "black dwarfs" since their luminosity L was expected to be extremely low ($L \rightarrow 0$) and their surface temperature T also very low ($T \rightarrow 0$).
3. It was also predicted by Dr. Kumar that the final radius of the stars with the mass below the H-burning limit is approximately 0.1Rsun (1,3).
4. Since the time-scale for the formation of these very low mass completely degenerate stars (black dwarfs) was calculated to be much less than the age of the Galaxy, Dr. Kumar predicted the existence of a very large population of "dark" objects (black dwarfs) in the Galaxy (4).
A more detailed account of Dr. Kumar's theoretical discovery, during 1958-1962, of the objects beyond the bottom of the main sequence is available on the Internet (9). Dr. Kumar has continued his work on the structure and evolution of stars beyond the bottom of the main sequence since 1962, and has published numerous scientific papers in the field founded by him. He also organized an international symposium on low-luminosity stars at the University of Virginia in March 1968. A major topic of discussion at this conference was the structure and evolution of the stars with mass below the H-burning limit. Many of the symposium participants referred to these objects as "Kumar objects" or "Kumar stars." The currently popular terminology of "brown dwarfs" was introduced in 1975. The proceedings of the symposium were edited by Dr. Kumar, and they were published as a book in 1969 (10). Observational searches for stars with mass below the Kumar limit (currently called brown dwarfs) were started in 1962 and they were finally detected in 1995! (11,12).
The 50th anniversary of Dr. Kumar's theoretical discovery of brown dwarfs was celebrated on October 21, 2012 at an international conference entitled "50 Years of Brown Dwarfs: from Theoretical Prediction to Astrophysical Studies" held at Ringberg castle, Bavaria, Germany (October 21-24, 2012). This conference was organized by the Max Planck Institute for Astronomy in Heidelberg, Germany. Information concerning this historical celebration event, organized by Dr. Viki Joergens and her colleagues/coworkers at MPIA-Heidelberg can be found here.(21)

VERY LOW MASS COMPLETELY DEGENERATE STARS AND DARK MATTER IN THE GALAXY (1962-69)

Dr. Kumar had already predicted in 1962 the possible existence of hydrogen-rich dark objects of very low mass in the Galaxy (4) and he continued to explore further that possibility during the 1960s. In a paper which was presented at the 1968 Symposium of Low-luminosity Stars and published in 1969 (13) he proposed a numerical value of approximately 0.001Msun for the minimum fragmentation mass for stars, and he then suggested that the number of dark objects with mass below the H-burning limit in the Galaxy is larger than that of visible stars.

MODEL ATMOSPHERES FOR LATE TYPE STARS (1962-1963)

Soon after joining NASA's Goddard Institute for Space Studies in February 1962, Dr. Kumar started a project for the study of the non-grey stellar atmospheres for late type (cool) stars, and he computed, for the first time, flux-constant radiative model atmospheres for stars with effective temperatures (Te) in the range of 2500-4000K and log g in the range of 2.00-5.00, where g is the acceleration due to gravity at the star's surface. These model atmospheres were found to have many interesting properties. Some of the more interesting results of this study are briefly discussed below:

1. The departure from greyness of the atmospheric material was surprisingly found to be very significant. Consequently, the computation of even one flux-constant model required a great deal of time on the Institute's IBM 7090 computer.
2. Most of the hydrogen in the atmospheres of cool stars was found to be in molecular form (H). This was a new result, but not totally unexpected.
3. For the first time, it was found that the free-free transitions due to H (negative molecular hydrogen ion) contribute significantly to the total opacity in the atmospheres of cool stars, particularly for dwarfs with effective temperatures less than 3000K.
4. A very sharp maximum at around 16,500A for the emergent continuum flux was predicted by the computed models. This result was communicated by Dr. Kumar to Dr. Martin Schwarzschild at Princeton University in late 1962, and, to test this prediction, the Princeton team observed a few red giants with the Stratoscope II infrared telescope during its second flight on November 26, 1963. Stratoscope II observations confirmed the predicted sharp peak at around 16,500A in the observed continuum of the red giants (14)! This prediction was also confirmed by ground-based observations (15). All of the above results were presented at the International Astrophysics Colloquium held at Liege, Belgium in June 1963. This paper entitled Model Atmospheres for Late Type Stars was published in January 1964 in the Colloquium Proceedings (16).

THE EXISTENCE OF THE FIRST-GENERATION STARS IN THE GALAXY (1961)

In a paper which was accepted for publication in the fall of 1961 and published in 1962 (17), Dr. Kumar proposed the existence in the Galaxy of a population of stars older than Population II stars. He referred to these older stars as "first-generation" stars in this paper. They were subsequently detected and they are now commonly know as Population III stars. The study of Population III stars has now become a very active field in scientific research, but it is generally not known in the scientific community that their existence was predicted in 1961.

THE ORIGIN AND EVOLUTION OF JUPITER (1962-1974)

In late 1962, Dr. Kumar started working on the formation of planets in the Solar System. He was particularly concerned with the origin and evolution of Jupiter. His tentative conclusion in the early 1960s was that Jupiter was not a collapsed gaseous object of mass 0.001Msun, and at two scientific meetings in 1966 (Conference on Low Mass Stars at Indiana University and the Colloquium on Late Type Stars at Trieste, Italy), he presented arguments for the formation of Jupiter (and other planets in the Solar System) by the processes of accretion of dust and gas in the vicinity of the Sun. During the 1967-1974

period, he published a few papers in which he developed his ideas on the formation of plants by the processes of accretion (18,19, 20). In particular, he proposed then that Jupiter was initially formed as a small rock and that it finally grew to its present size by the processes of accretion of matter (dust, gas, rocks, etc.) by a solid core (the initial Jupiter). Since 1974, Dr. Kumar has continued his work on the origin and evolution of Jupiter (and Saturn) and this work will be discussed in a more detailed biography currently in preparation.

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(An account of the 50th anniversary celebration event at Ringberg castle, Bavaria, Germany on October 21, 2012 of Dr. Kumar's prediction of brown dwarfs.)