# INTRODUCTION

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Your Magnificences, my Lord Mayor, ladies and gentlemen! It is a great pleasure for me to respond, on behalf of your foreign guests, to your gracious words of welcome; and to thank you for the wonderful reception which you have extended to us. The city of Bamberg and its Remeis Sternwarte has indeed been renowned all over the world for a great many years - as the place where your Observatory's first director, Professor Ernst Hartwig (1851-1923) - in addition to his other titles to fame - collaborated (with Gustav Müller of Potsdam) on the construction of the monumental Geschichte und Literatur des Lichtwechsels der Veränderlichen Sterne, which since 1918 has (together with its subsequent continuation) been a veritable vade-mecum of all students of variable stars; where the second director, Professor Ernst Zinner (1886-1970) prepared his valuable Katalog der Verdächtigen Veränderlichen Sterne (1926) which safeguarded many an astronomer (including the present speaker in the days of his innocence) from premature discovery claims; and whose third director, Professor Wolfgang Strohmeier, initiated in 1959 the tradition of the international colloquia of which ours is the latest successor. It is indeed a great pleasure to welcome Professor Strohmeier - now Emeritus - among us; and to congratulate him on the grace with which he is carrying his years. And - last but not least - it is a very pleasant duty to express our sincere thanks to his successor, Professor Jürgen Rahe, and to the Bamberg city authorities, for their invitation to hold our meetings in their lovely town, which for many years has been the place of periodic pilgrimage to so many students of variable stars - and we sincerely hope it remains so also in the future.

The presence of so many of you here this morning - with participants from 20 countries ranging geographically from California to Japan, and from Finland to South Africa, in the days when travel is no longer as easy to wage as it may have been before, bespeaks the attraction and affection which Bamberg holds for the international astronomical community. It demonstrates the truth which the great German poet Friedrich Schiller (whose last resting place is not too far north of us today ) expressed in his ode An die Freude - later rendered so



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strikingly into music by Beethoven - which could equally have been addressed to our muse Urania... "Alle Menschen werden Brüder wo dein sanfter Flügel weilt". This is certainly true today in this room; and may it remain so anywhere in the world also in the future wherever students of science congregate to discuss their heavenly problems - whether or not these are concerned with double stars!

The subject of our colloquium "Binary and Multiple Stars as Tracers of Stellar Evolution", calls perhaps for a few words of introduction. As is well known, binary stars in the sky represent limiting cases of stellar associations, consisting of gravitationally-bound systems whose components originated virtually simultaneously and from material of very much the same initial composition; although their components could at the time of their origin have possessed arbitrarily different masses. Ever since early 1950's - when the nature of stellar evolution was placed on a (plausible) nuclear basis - we have known that the progress of nuclear evolution depends essentially on the star's mass (and, therefore, internal temperature); its rate being the faster, the larger the mass of the respective configuration. The occurrence, in the sky, of large number of the pairs of stars whose components are of equal age and initial composition, but possibly of different mass, offers a veritable royal road for tracing the effects of differential evolution caused by a difference in mass alone. In particular, on the commonly accepted basis of nuclear evolution we should expect the evolution of more massive components to proceed more rapidly than that of their less massive mates.

The observed properties of double stars seem, however, to bear out a rather different story; for while theoretical expectations are broadly in harmony with observations of binary systems whose both components belong to the Main Sequence, for systems in which at least one component evolved away from this sequence, the opposite of what theory alone would lead us to expect turned out to be true: namely, the component whose observed attributes identify it as a more evolved object invariably happens to be the less massive of the two.

Since the mid 1950's, when this "evolutionary paradox" was first pointed out (cf. Kopal, 1955; or Crawford, 1955) and made the subject of specific discussions, the problem of accounting for this peculiar behaviour has been exercising our minds; and many conferences were devoted in the past in an effort to establish its satisfactory solution. Our present colloquium will, however, differ from its predecessors in one important aspect: namely, while all past conferences concerned with evolutionary aspects of double (or multiple) star systems focussed attention almost exclusively on "close" binaries (mainly of those which manifest their nature by mutual eclipses of their components), we shall endeavour to bring into a common focus the evolutionary behaviour of all binary stars from which the relevant data are available - whether these binaries are "close" or "wide" (i.e., "visual") in the accepted sense of the word. For all such binaries - wide as well as close - consist of components which are (most probably) of the same

age and initial composition; and whose mean lifetimes are longer than the age of the Galaxy - regardless of whether their components are separated by $10^{-2}$ or $10^{4}$ astronomical units (cf. Chandrasekhar, 1944; or Kopal, 1978) - so that the effects of their differential evolution going back to an initial difference in mass, can be traced for time intervals up to $10^{8}$ - $10^{9}$ years.

Do all such binaries - close as well as wide - exhibit indications of the same "evolutionary paradox"? The answer - which did not seem to have attracted sufficient attention - appears to be in the affirmative: at least the extent of the evolutionary paradox in (say) Algol or U Sagittae is no more pronounced than it is in wide ("visual") binaries like Sirius or Procyon - to name only a few among the nearest stars - whose (at present) less massive components far out-distanced their more massive mates in their evolutionary courses; and while the latter still linger on the Main Sequence today, their less massive components have already become white dwarfs. Moreover, perhaps the most flagrant paradox of this kind is encountered among X-ray binaries, several of which were discovered in the sky in the last decade; and about which more will be said in later parts of this colloquium.

In order to bring about so profound a metamorphosis of the role of the components, it is inevitable for the more evolved star to have once been the more massive of the two; and since it is no longer one today, it should have lost a large part of it (up to 90% for X-ray sources) some time before. There is no room for doubt that this must have been the case if we are to reconcile the presently observed properties of binary systems with the basic properties of the current stellar models, requiring that the more massive body is bound to evolve at a faster rate.

The actual mechanisms by which a star in post-Main Sequence stage can divest itself of a large fraction of its mass are still largely uncertain; and so is the mode of disposal of excess mass - whether it escapes from the system at high speed, or whether (in the case of low-velocity escape) a part of it can be captured by its mate. Such questions will no doubt come under discussion during subequent sessions of our colloquium. But whatever may be the more detailed outcome of such discussions, one more general conclusion may be of overriding importance; namely, if the above-described "evolutionary paradox" is characteristic of all binaries alike - be these close or wide, and if (as seems logical) its origins are to be sought in terms of the same physical process operative in all binaries alike - be these close or wide - the proximity of the components cannot be the main cause of the observed phenomena; or could, at best, play only a subordinate role.

It is mainly to throw more light on these questions that our colloquium has been convoked, and its programme organized. In the first session which is to follow these introductory remarks, Professor

Rudolf Kippenhahn and the speakers following him will discuss the evolutionary trends of single stars in their post-Main Sequence stage, on the background of which we can attempt to trace also the evolution of components in the binary systems. The second session, to be introduced by Professor Peter van de Kamp, will be concerned with a survey of observed characteristics of wide binaries; while session 3, which will be introduced by Professor Miroslav Plavec, will be similarly concerned with photometry and spectroscopy of close binaries; with special attention devoted to "contact binaries" of W UMa-type. Ultimately, the fourth (and last) session, to be introduced by Professor Remo Ruffini, will be devoted to binary systems at the extreme end of stellar evolution - and, in particular, to the enigmatic object SS 433 - which provided in recent years more excitement in double-star astronomy than any other type of systems - an excitement which will no doubt be shared by all participants of this colloquium. The satisfactory solution of all problems arising in this connection will no doubt have to await the acquisition of additional observed data, and further theoretical developments will be necessary before their solution can be placed on a truly satisfactory basis; to contribute towards this goal should be the principal aim of our colloquium.

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