Foreword

The solar cycle has been studied for over 100 years in its more obvious manifestations. However, it is only in the last decade or so that it has been possible to verify the plausible assumption that the Sun is a typical, albeit rather unspectacular, lower main sequence star, in the sense that analogues of the solar cycle are common if not universal amongst stars of similar age and mass. These developments have generated a new area of astronomy, loosely termed the "solar-stellar connection", that has shown almost exponential growth during this period. IAU Symposium 102 in Zürich in 1982 was perhaps the first IAU meeting to be substantially devoted to stellar activity and it may be of some interest to compare the Proceedings of that meeting with these to assess the progress (or otherwise) made since then! During the intervening period a great quantity of data has been amassed by a variety of observational techniques, both traditional and innovative, using the entire accessible spectrum. New measures and indices of stellar activity have been developed (spectroscopic, photometric, polarimetric) and, perhaps most remarkably, the union of state-of-the-art observational technology with the power of supercomputers is now making possible the direct modelling of temperature and magnetic features on stellar surfaces.

At the same time our knowledge of processes occurring within the Sun that are related to the solar cycle has increased substantially. At one time our sole knowledge of the solar velocity fields came from studying the different rotation laws of various surface features. Now helioseismological studies are revealing more directly the angular velocity law in the solar interior, and they have also helped to establish the position of the base of the convection zone – essential information for theoretical modelling. Our ability to measure surface flows has increased, although this area is not without controversy.

On the theoretical front, there has been an increasing consensus (with one or two dissenters) that the engine of solar and stellar activity is a "turbulent dynamo". The modern concept of such a dynamo goes back to the work of Parker, Babcock and Leighton, but in the last decade numerical and analytical investigations have burgeoned. Two basic approaches can be identified, the highly parameterized "mean field" dynamos introduced by Steenbeck, Krause and Rädler and the computationally much more expensive simulations pioneered by Gilman and Miller. A major problem with studies of the solar cycle and solar dynamo has been that the Sun is just one realization for one set of parameters of an active star. Any dynamo/turbulence theory has enough parameters that achieving a fit of a model to one object cannot provide a conclusive test of the theory. (Nevertheless, even this limited objective has not yet been achieved!) Now that enough active stars have been observed to begin to deduce some meaningful statistical relations between the various parameters – cycle periods, rotation periods, spectral type, etc. – there is a real possibility of subjecting candidate dynamo theories to a proper examination.

Bearing all these factors in mind, one of our main intentions when planning this meeting was to bring observers and theoreticians face to face. This would, at the

very least, give everyone an opportunity to appreciate each other's problems, and with this insight to reflect on the direction of their own work. The ultimate goal must be, of course, to confront theory and observation and to examine whether theoretical models are well founded. We thus deliberately gave a substantial emphasis to theoretical studies, including those on the basic theories of magnetohydrodynamic turbulence that underpin any model of a dynamo operating in a stellar convection zone. It should give those who use mean field models some pause for thought to realize how little is known about the turbulent fluid properties that they casually subsume into turbulent transport coefficients, α-effect and so on! These contributions are found in Section I. Section II deals with stellar dynamos in general and specializations to the solar case are found in Section III, together with relevant observational contributions. The lengthy Section IV is given over to the various studies of stellar activity and its relation to the solar cycle. Generally, the ratio of theory to observation is a decreasing function of page number.

Readers of this volume must surely be impressed by the progress, both theoretical and observational, that has been achieved in the last 10 years. Nevertheless a heretic might be excused for asking whether observers and theoreticians are always talking about the same objects! In the solar case there have been substantial efforts to model the "real Sun", but even then the most sophisticated models represent a physical system that is by orders of magnitude less complex than reality, and fail to reproduce successfully all the basic features of the solar cycle. For other stars, in the continuing game of leapfrog between observations and theory, the observations are a clear jump ahead.

After all the discussions about how the solar cycle is similar to those of other stars, and the current inability of theory to produce convincing models of these cycles, it was refreshing to end the meeting by observing one phenomenon that plausibly is unique to the Sun and is also highly predictable – the total solar eclipse of the morning of Sunday July 22.

Some of the contributions were received as TeX files that had been prepared by the authors using the Springer TeX macro. Others were retyped or reformatted during the editing process; the Editors accept responsibility for any errors that were introduced at this stage. It was not possible to include all the submitted material in these Proceedings. The Editors apologize to those authors whose contributions do not appear.

The assistance of Mr. Reino Anttila in retyping a substantial part of the text of this volume is gratefully acknowledged. Many people contributed in one way or another to the success of the meeting. The Editors' thanks are due to them; their help made possible the eventual production of this volume.

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Helsinki, January 1991 The Editors