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Claudio Vita-Finzi

Solar History

An Introduction

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For Raphy and Sam

Preface

Approximately 5,000,000,000 years from now the Sun will exhaust its supply of hydrogen and turn into a red star so bloated that it swallows the planet Mercury and so hot that it melts the Earth's surface. That much is generally agreed upon. But what the Sun will do next year, let alone the next decade, is not at all clear. It will not be much bigger or nearer to us than now, and its net output will probably not depart from the average of the last few decades by more than a few tenths of one percent, but by how many tenths, and will the contribution of ultraviolet rays increase or decrease, and in either case how rapid will the departure be?

The answers bear not only on climate change but also on human health and the many activities—including the rest of astronomy, radio and satellite communications, geodesy and Space travel—where small changes in the Sun can have a disproportionate impact. To tackle these questions we require a secure grasp of the Sun's entire evolution so that long-term trends as well as short-term fluctuations can be properly assessed.

But solar history needs no utilitarian justification. It bears on our planet's evolution, and that of its occupants; it reflects events throughout the solar system; it illuminates the fate of the billions of stars in the Milky Way and beyond; and it illustrates the noble achievement of those who are making sense of an incandescent ball of gas with a volume a million times the Earth's and distant enough for its light to take 8 min to reach us. D. W. Hamlyn once suggested that a history of philosophy, apart 'from the strictly historical sense....ought to provide a due sense of the complexity and many-sidedness' of its subject. That is what I had in mind when writing *Solar History*.

Solar history is extremely uneven. Documentary sources are available for only 0.00001 % of the Sun's existence. For the remaining 4.5 aeons we depend on analogy with other stars, computer modelling, data derived from meteorites, polar ice caps and tree rings, the fossil record, and other indirect guides to solar behaviour. In *The Sun—a User's Manual* (2008) I hinted at these matters but necessarily focused on the present day while claiming that a history of the Sun was beginning to fall into place. There had in fact been three magisterial multiple-author surveys of the solar past [1–3], but much new information has been skilfully (and expensively) secured in the last two decades which bears on parts of the narrative.

I am indebted to Penelope Vita-Finzi for encouragement, Ken Phillips and Ilya Usoskin for their sage comments on parts of the text, Dom Fortes for reading the whole thing, Michael Wood for compassion, many individuals and organisations—above all NASA—for data and images, and Petra van Steenbergen at Springer for support.

Fenstead End, Suffolk, May 2012 Claudio Vita-Finzi

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Contents

Chapter 1
Introduction

Abstract Solar History traces the Sun's evolution from the origins of the Solar System some 4,500,000 yr ago to recent months. In doing so it fuses the data of astrophysicists with those of observational astronomers, field scientists and historians. The subject matter thus spans a wide range of timescales, from the aeons (Gyr, 10^9 yr) of the solar modellers to the millions of years (Myr, 10^6 yr) in which much of solar history is read from meteorites, the millennia and centuries (10^5–10^2 yr) documented by ice cores, tree rings and sunspots, and the decades, years, days and seconds (10^1–10^{-9} yr) of telescopic and satellite observational astronomy.

Keywords Solar history · Solar model · Meteorite · Ice core · Tree ring · Sunspot · Observational astronomy · Neutrino

The observational history of the Sun began with the systematic recording of sunspots 400 years ago; we have to use indirect sources to document the remaining 4,499,600 years, and many of those sources involve meteorites, ice cores and sediments rather than the kind of data conventionally handled by astronomers and astrophysicists. Such terrestrial data may well help to uncover evidence for solar variation that will help astrophysicists understand the internal dynamics of the Sun [9].

We have to deal with evidence at widely varying degrees of precision. Our knowledge of events in the earliest 4.5 Gyr appears sketchy and that of last year abundant. This would be a crude way to apportion space in a narrative, as sketchiness is a misleading term when we are dealing with cosmic dimensions and abundance does not always breed understanding. It seems more informative for successive chapters to discuss solar history at the appropriate resolution ranging from Gyr to minutes and seconds. As a crude analogy, consider the benefits that have come from juxtaposing the scanty evidence for the first few million years of human evolution with the physiology and behaviour of living individuals.

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