WORKSHOP INTRODUCTION

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Why this workshop?

Why this workshop? Or rather, since the real question that arose about a year ago was not whether there should be another OAC workshop, but only what it should be about: *why a workshop on granulation*?

To answer this question I will play an unfair trick on you. I will simply present the scientific justification which I included last autumn in a grant application to NATO's Scientific Affairs Division. It lists the reasons why I thought a workshop on this particular topic and at this particular moment ought to be worthwhile. There must be something in its reasoning, because NATO has indeed agreed to co-sponsor this workshop, and because all of you have decided to spend time and effort on your contributions and to journey to this beautiful island in order to participate. But since the proof is in the pudding, I am eager to see whether indeed this workshop will be as outstanding as I have promised; in the meantime, you are entitled to know what we got you here for.

The justification went as follows:

"The subject 'granulation' has recently become a hot topic, at the center of much new research, observational as well as interpretational and theoretical, and both in solar physics and in stellar physics.

The reason for the renewed attention for this phenomenon (after all discovered on the sun already a century ago) is that recent advances have occurred, fortuitously simultaneous, which now enable a transition from morphological description to detailed physical interpretation: the subject is becoming of age.

The solar granulation becomes the first example of a coming solar physics revolution: providing insights that can only be obtained by studying the sun with high spatial resolution. This era of studying basic physical processes rather than the phenomena they cause starts now. This is extremely important for all of stellar physics because the sun is the Rosetta stone of astronomy: it is the place where the processes can be identified and understood that are the machinery of astrophysics in general.

R. J. Rutten and G. Severino (eds.), Solar and Stellar Granulation, 1–5.

Granulation is the signature of the convection that transports the stellar energy flux through the outer parts of all cool stars. Furthermore, it is now clear that it is also the agent which sweeps the concentrations of intense magnetic field which most cool stars possess, into the patterns of solar and stellar activity which underly the existence of the hot nonthermal chromospheres and coronae. The hydrodynamical, MHD and plasma processes that interact in the formation, heating and instabilities of these highly complex layers together represent a unique astrophysics laboratory for us to understand. The granulation is an important part of the engine and the main structuring agent in layers where the magnetic field is still frozen in. Knowledge of how granulation acts in stars that differ from the sun adds to our understanding of stellar structure.

The recent advances are:

- *Space Observation.*
  The last successful flight of *Challenger* carried Spacelab 2 with the SOUP instrument. It made the first granulation movie that is free from atmospheric image degradation, enabling granule astrometry. The reduction and analysis are in full swing; important results are in press.

- *New mountain-top solar telescopes.*
  The realisation that the future of solar physics lies in resolving the basic processes has led to the design of new telescopes specifically built to obtain maximum spatial resolution at the best sites worldwide. Granulation is their top priority subject. The Swedes have completed a small but superb solar telescope at the Roque de las Muchachos Observatory (La Palma). The first granulation studies are in and very exciting. The Germans are installing two major telescopes at the Izaña Observatory (Tenerife). The first one has started granulation studies and the second one will do so soon.

- *New observational techniques.*
  A forefront of new technology is exemplified by the development of active optics, enabling real-time correction of atmospheric image distortion. A prime target (outside SDI) is to enable correlation tracking of solar granulation (Sacramento Peak, Lockheed). The only solar telescope which reached high resolution before is the Pic du Midi refractor. It has now been equipped with the Meudon subtractive multi-slit spectrometer, enabling detailed two-dimensional mapping of intensity and velocity patterns strictly simultaneously.

- *Stellar observations.*
  Although there are typically a million granules on the visible hemisphere of a star, their averaged-together velocity signatures can now be measured using precision spectrometry. Presently, granulation is studied for a number of cool stars.

- *Supercomputer simulations.*
  An important breakthrough has been reached: ab-initio self-consistent modeling of the solar granulation has been achieved using supercomputers, which serves to interprete and diagnose the new observations in detail. This work is now being extended to numerical simulations of prototype stellar convection.

- *MHD theory.*
  The discovery that most magnetic field on the sun (and on other cool stars) exists in very strong concentrations has led to the 'fluxtube' concept and a large amount of theoretical study. At the moment, the interplay between granular buffeting and tube instabilities attracts much attention. On a larger scale, the role of the granular velocity fields in patterning the activity phenomena poses important theoretical questions.

- *Future projects.*
  Currently, two large-scale programs are being defined that both have solar granulation high on their list. The first is the LEST, the large solar telescope to be sited in the Canary or Hawaiian islands which is now being designed by a large international consortium. It will be the major ground-based solar physics facility of the late nineties. The second is NASA's Orbiting Solar Observatory, successor to the SOT and HRSO projects, which aims to put a major solar telescope in orbit in the mid-nineties. It will be the major space-based solar physics facility of the late nineties.

All these developments together make an expert workshop on solar and stellar granulation highly desirable, to review what is going on, to consolidate new results, and especially to provide a road map for future work."

This is what I promised to NATO, and hence, this is what you are supposed to do here!

Historical review

One talk that is missing on the program of this workshop is a historical review. This may seem strange for a field with such a long history of scientific endeavour, and indeed Peppe Severino and I originally planned to start the meeting with one. However, we canceled it when it became clear that the colleague whom we invited as reviewer would not be able to come, and also that we would be short on time in this morning's 'Telescope Caleidoscope' session. As compensation I will now give you a very brief historical review, consisting of two transparencies only.

The first one shows one of Father Secchi's beautiful drawings[1], to remind you that high-resolution imaging is not new under the sun.

The second shows a table taken from the monograph of Bray, Loughhead and Durrant. It summarizes the history of solar granulation studies from Herschel's first description until Project Stratoscope. I am happy to note that it mentions two participants of this workshop—Constantin Macris and Jean Rösch.

[1]Reproduced as frontispiece.

1.7	**Chronological summary**
1801	W. Herschel uses the term 'corrugations' to describe the mottled appearance of the solar disk.
1862	Announcement of Nasmyth's 'willow-leaf' pattern.
1864	Dawes introduces the term 'granule'.
1866	Publication of a paper by Huggins ends controversy over Nasmyth's 'willow-leaves'.
1877	Granulation successfully photographed by Janssen.
1896	Publication of Janssen's collected observations.
1908	Hansky estimates mean lifetime of granules to be about 5 min.
1914	Publication of Chevalier's collected observations of the granulation.
1930	Unsöld attributes the origin of the granulation to convection currents in the hydrogen ionization zone.
1933	Announcement of Strebel's discovery of the polygonal shapes of the granules.
1933	Siedentopf formulates a theory of the granulation based on Prandtl's mixing-length theory of turbulent convection.
1936	H. H. Plaskett identifies the granules as Bénard-type convection cells.
1949	Richardson obtains spectra showing the Doppler shifts of the granules.
1950	Richardson and Schwarzschild identify the granules as the eddies of a large-scale aerodynamic turbulence.
1953	First reliable determination of granule lifetimes made by Macris.
1955	Various workers claim that the solar surface shows random brightness fluctuations, not a cellular pattern.
1957	Rösch publishes granule observations made at the Pic-du-Midi.
1957	High-resolution photoheliograph brought into operation near Sydney by the CSIRO.
1957	Leighton re-asserts convective origin of the granulation.
1957	Granulation photographed from a manned balloon.
1957	Project Stratoscope I yields granulation photographs of unsurpassed definition.

Figure 1: Table 1.7 from R.J. Bray, R.E. Loughhead and C.J. Durrant, 1984, *The Solar Granulation*, Cambridge University Press, second edition. Permission granted by the publisher

The monograph furnishes an excellent survey of the developments since Stratoscope, in which many of you have taken part. There is no point in summarizing them here: we will re-address them in detail while we "review what is going on, consolidate new results, and provide a road map for future work". Let us begin!

Part 1

Observational Techniques