VERY LARGE TELESCOPES AND STELLAR ASTROPHYSICS

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1. Introduction

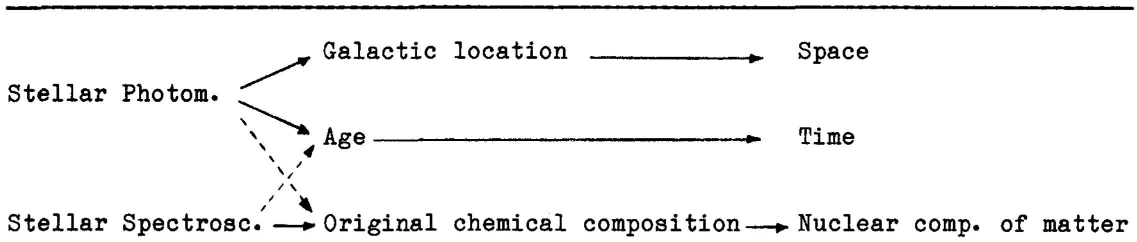
Let me start by reminding you in a very general frame what kind of information we expect to be able to derive from the observation of stars.

First of all, there are observations - of photometric nature - which allow us to detect the location of stars in the sky. Modern astrophysics enables us, in the general case, to add more or less stringent information on the star distances. On the whole, one reaches in this way a picture of the galactic distribution of stars, i.e. information on the space location.

A second kind of information we can derive from photometric measurements is that concerned with the age of stellar objects. As is well known, this is done - mainly - by constructing HR diagrams for stars which are members of stellar clusters.

Last, but not least, the spectroscopic approach allows us to obtain information on the chemical composition (i.e. on the distribution of nuclear species) in the stellar atmosphere. A "datum" to be handled bearing in mind that it represents - in the large majority of cases - the original chemical composition of the clouds from which the star was formed.

Previous considerations can be condensed in the following scheme:



Dotted lines, connecting spectroscopy with age and photometry with chemical composition, have been used as a reminder that the frame we adopted is just a first approach to a rather complex problem. As a matter of fact, in many cases we need a good knowledge of the chemical composition in order to interpret the

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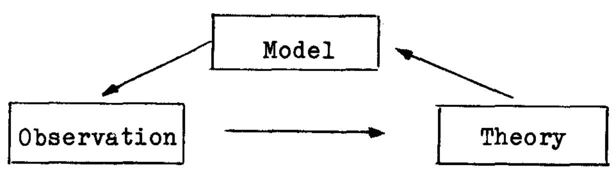
photometric data in terms of ages. And, on the contrary, in some cases we are forced to use photometric data to reach conclusions about the original chemical composition, as in the well known helium problem concerning galactic globular clusters.

In any case, if and when the complete set of stellar information becomes available, we are able to conclude that "in such a galactic location, so many years ago, there was a cloud with such a chemical composition". Thus we are driven to the natural goal for "stellar astrophysics":

"Mapping the dynamical and chemical evolution of galactic matter (i.e. mapping the history of our Galaxy), in order to understand what heppened, how and why."

Such an investigation spontaneously proceeds following a three-step procedure, where observations produce theories and, in turn, models to be further compared with observations.



In this frame, we have now to debate which improvements we can expect from VLTs.

2. The stellar performances of VLTs

It was recognised early that VLTs are not particularly "skilled" in reaching very faint stars. This will be, of course, a job for Space Telescope.

I will take a list of the advantages of VLTs as given by Appenzeller in the recent meeting of Cargèse (1983). By indicating with D the "effective aperture" of a telescope, one has:

Time resolution	$(\Delta t)^{-1} \sim D^2$	(S/N = const.)
Spectral resolution	$\lambda/\Delta\lambda \sim D^2$	(S/N = const., Δt = const.)
Distance	$d_{max} \sim D$	($\lambda/\Delta\lambda$ = const., Δt = const., S/N = const.)

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To fix our ideas about the significance of these advantages in terms of real observations which become available, let me use the figures given by Nissen (1983) concerning the limiting magnitude with 3 hour exposures, $\Delta\lambda = 0.2$ Å, S/N = 30. By comparing the performances of a 3.6m with those of a 12.0m, one obtains

Aperture	3.6m	Limiting magnitude	$17^{m}.5$
"	12.0m	" "	20.1

Figs. 1 and 2 disclose the consequences of these two choices. One realises that in the case of a young open cluster like Praesepe a 12.0m telescope will enable us to reach a good deal of the White Dwarf sequence, collecting new and important data on this evolutionary phase. As far as Population II clusters are concerned, fig. 2 shows that the improved limiting magnitude will allow us to obtain detailed spectral information about practically unevolved stars below the turn-off, throwing light on some open questions, like the degree of chemical homogeneity in the original cluster population.

3. Goals for VLTs

Summarizing the advantages expected from the use of VLTs, one has:

i) Shorter exposures, or
ii) higher resolutions, or
iii) larger distances, or
iv) any suitable combination of i), ii) and iii).

As far as point i) is concerned, one easily realises that shorter exposure means not only more exposure in the same time but also the opportunity to detect more rapid phenomena in stellar atmospheres. In other words, we expect VLTs to be of great importance in the study of "stellar activity".

It may be worthwhile to emphasize that the word "stellar activity" can be related to two very different frames. The first, which has been (maybe) the most popular in recent times, is the one concerning what I will call "the pathology" of stellar structures, i.e. X binaries, neutron stars, black holes, etc. The second one, which I will indicate as "physiological activity", concerns stellar activity in normal stars, during their normal life as single but important actors in the history of galaxies and of the Universe.

I hope that such a "physiological activity" will be among the more urgent objectives of VLTs. As a matter of fact, the physics of stellar surfaces is, in some respects, the most important "black hole" in stellar astrophysics. As an example, I wish to remind you that, at present, we have not yet any firm conclusion about the mechanism governing mass loss from stars. Neither have we

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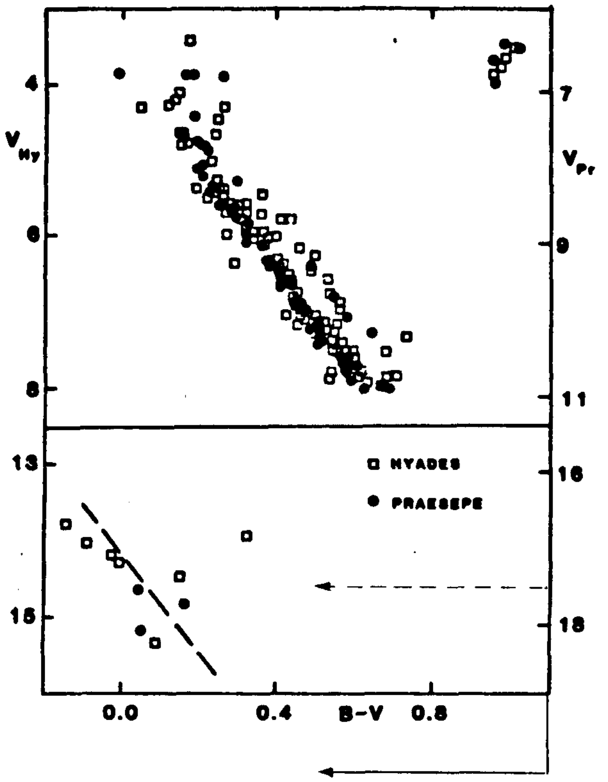

Fig.1 Color-magnitude diagram for the Hyades and Praesepe clusters, showing the MS and WD sequences (Anthony-Twarog 1984).

Dashed and black arrows indicate the limiting magnitude for spectroscopy with present and VL telescopes, respectively (see text).

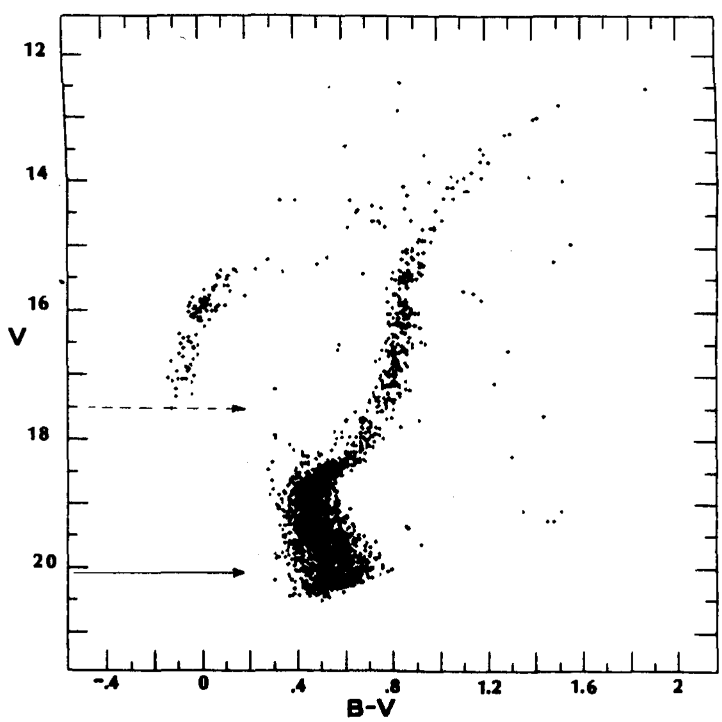

Fig.2 As in fig.1 but for the globular cluster NGC288. Color-magnitude diagram from Buonanno et al.(1984).

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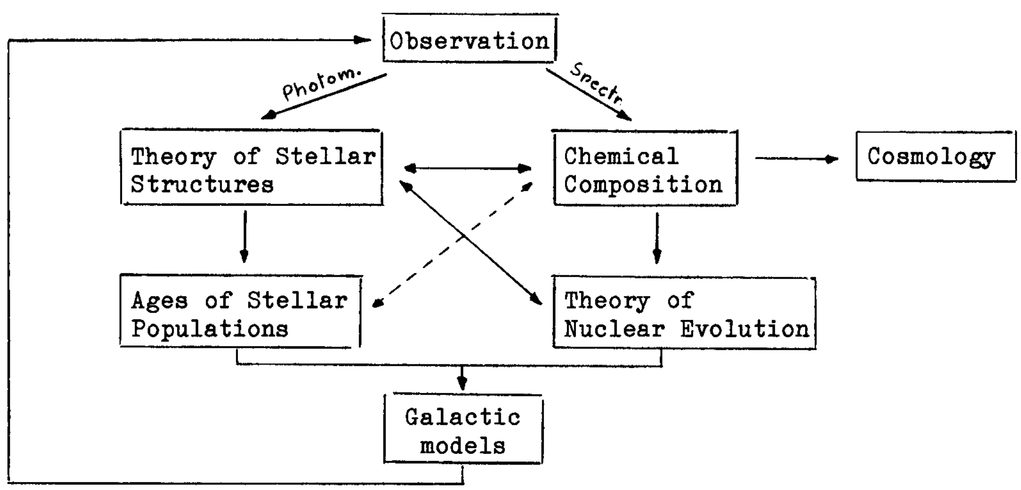
any clear ideas about the role played, in this context, by pressure radiation, convection, rotation and/or magnetic field. This, in spite of the fact that mass-loss is governing stellar evolution, determining, e.g., which stars will become WDs, which will undergo C-detonation, and which will end the evolution as SN or as black holes. This is the reason why, to my mind, the most important step to be taken in the future is to acquire a deep knowledge of the surface activity of quiescent stars.

As far as the more general problem is concerned, stellar astrophysics is at present a rather sophisticated discipline, so that it is not easy to sketch in a few words the expected impact of VLTs. The best I can do is to put down the previous diagram regarding stellar astrophysics procedures with some more details:



where VLT advantages will be spread around. In the next section we will deal with some examples which throw light on this problem. Here, I wish to emphasize a very general "heading".

"We are at the end of a period during which the properties of the stellar content of our Galaxy have just been checked. Now we begin to be able to fix our ideas and to construct reliable working hypotheses: Now we need statistics".

VLTs are expected to accomplish this task.

4. Some selected goals

Let me briefly discuss some examples illustrating the field of application of VLTs.

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4.1. <u>Nuclear distribution:</u> Until recently the abundance in iron, [Fe], has been taken as an indicator of the nuclear evolution of matter, marking its "genetic distance" from the big bang. This was done under the assumption that all heavy elements behave as Fe , being produced in the same events and with proportional abundances. There is now increasing evidence that this is not always true. In particular the evidence is increasing that metal poor stars in the galactic halo tend to be overabundant in elements like oxygen. A detailed knowledge of the nuclear distribution among the various stellar populations is thus of primary importance, throwing light on the characteristics of stellar populations which contributed to the nuclear yields.

VLT GOAL 1: <u>Survey of the path of nuclear evolution of the galactic matter.</u>

4.2. <u>Survey of the galactic halo:</u> Deep survey of stellar fields in the galactic halo have recently been obtained, also in connection with extragalactic astronomy. The observation (fig. 3) shows that halo stars arrange in a HR diagram following a strip with well defined boundaries in colors.

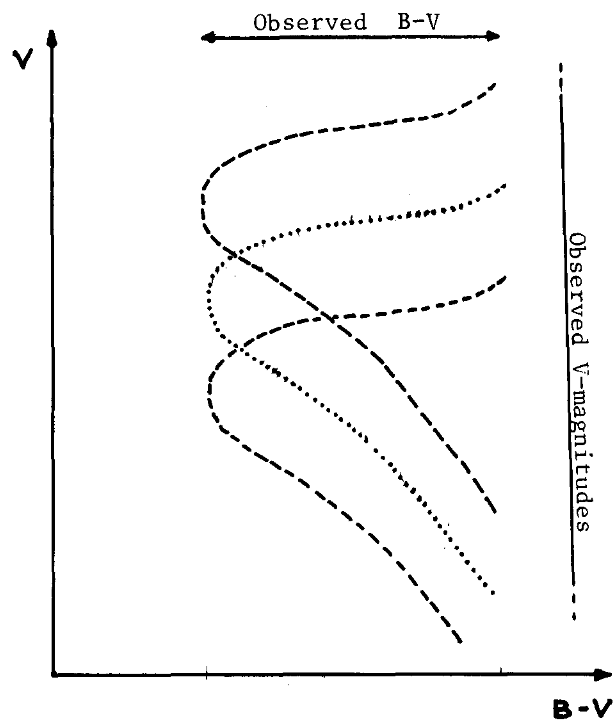


Fig.3 The HR diagram distribution of halo stars is due to the contribution of typical Pop.II stars from various distances.

This result can be easily identified as due to the contribution of typical Population II stars from various distances (fig. 3). It turns out that stars at the blue edge of the strip should be turn-off stars with a magnitude $V \sim 4^m$ (see Castellani et al. 1984 for a more detailed discussion). It turns out that blue stars can be used as standard candles for mapping the halo.

VLT GOAL 2: Spectroscopy of the "candles" to study metallicity gradients.

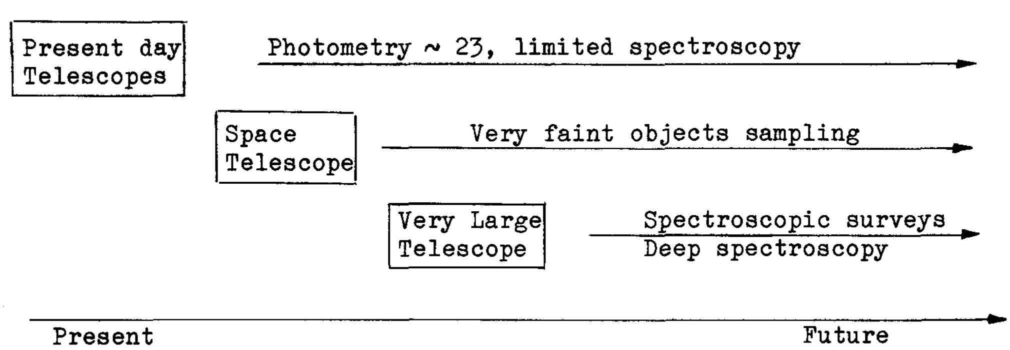
4.3. Globular clusters: Morphology of the blue end of HB in galactic globular clusters is an important parameter to be connected with some open questions like the occurrence of UV bright clusters and the so-called "second parameter" problem.
Spectra of blue HB stars have recently been proved to be extremely useful for analysing this problem in the near cluster NGC 6752 (Caloi et al. 1984).

VLT GOAL 3: More spectra in more distant clusters.

Please remember that these are only three of the many examples one can give concerning the problem of VLTs and stellar astrophysics.

5. Conclusion

What I think about the future observatory in the field of stellar astrophysics is reported in the following diagram.



It can be summarized in a simple statement: VLTs will join ST to allow us to fully exploit the observational capabilities in order to complete, as far as possible, the observational frame we need to solve the problem of stellar astrophysics: the history of the Galaxy, and of galaxies in the Universe.

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DISCUSSION

D. Baade to V. Castellani: As another field of stellar astronomy with a VLT, I would like to mention stellar seismology which is the only way to "observe" the internal structure of stars. Stellar seismology was until recently limited to radial and low-order non-radial pulsations, except for the Sun where on the resolved disk also very high-order nonradial modes are observed. Similar work can be done for stars if the resolving properties of rotational spectral-line broadening are exploited. A practical (tested) limit for observations with ESO's 1.4m CAT of m=10 modes with periods around 0.1 day is $m_V \simeq 4^m$. It seems feasible to search for modes with m up to ~40. This requires ~4 times better temporal resolution and a ~5 times better S/N, i.e., 100 times more photons. Thus, the limiting magnitude for this kind of work with 15m telescope would still only be $\sim 4^m$.

J. Tinbergen to V. Castellani: When you have exhausted the possibilities of increased spatial and spectral resolution, one way to further progress is higher precision of intensity measurements (fainter spectral lines, better line profiles, polarization). This requires more photons, therefore a job for a VLT. It requires a "clean" telescope, one that presents the incident radiation, unmodified except for concentration, to the analysing instrument. Now, in general, a single telescope will be "cleaner" than an array used as a single unit. Until detectors become completely noise-free, this has a bearing on VLT design.

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