MAD Science Demonstration Proposal

The Magellanic Clouds

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Abstract:

We propose to observe two regions in the Magellanic Clouds where suitable asterisms exist to obtain deep IR Colour-Magnitude Diagrams (CMDs) in crowded regions reaching down to the oldest Main Sequence Turnoffs (MSTOs). These data will provide the deepest IR CMDs of the resolved stellar population in a nearby galaxy. This proposal is also an important step in defining the limits of accurate photometry of faint stellar objects in deep wide field AO imaging, which has implications for understanding the potential of ELTs to make accurate CMDs of resolved stars in distant stellar systems.

Scientific Case:

There is much that we can learn about galaxy formation and evolution back to the earliest times from the *archaeological* evidence in the properties of individual stars. Stars provide an accurate and detailed measure of how the rate of star formation and chemical composition of a galaxy varies from its formation to the present and thus how galaxies evolve. To accurately determine these properties detailed CMDs of resolved stellar populations are required in combination with modelling and analysis techniques; providing the link between the local universe, high redshift surveys and theoretical simulations of galaxy formation and evolution (e.g., Tosi et al. 1991, AJ, 102, 951; Tolstoy et al. 1998 AJ, 116, 1244; Aparicio & Gallart 2004 AJ, 128, 1465)

The most accurate CMDs include stars down to the oldest MSTOs ($M_I \sim +3.5$), because this is the region where the old populations are distinct from each other, and not overlapping, unlike on the Red Giant Branch. It is not completely clear what is the ultimate sensitivity that can be attained with MAD and so we would like to push as deep as possible in a reasonable amount of time (∼1 hour, on target plus over heads). From the NACO ETC we assume this to be about 2 hours of telescope time per pointing, and this should reach the oldest MSTOs in the Magellanic Clouds in JHK with a reasonable S/N (∼ 15).

NGC1928 is a well studied LMC globular cluster for which optical HST/ACS data exist (Mackey & Gilmore 2004 MNRAS, 352, 153). NGC 371 is an open cluster in the SMC which is poorly studied to date and these data will allow an opportunity to look more carefully into this crowded central region of the SMC. In both cases we will combine MAD photometry with existing optical imaging to compare our results to more established analyses and to confirm the accuracy of the MAD photometry at faint levels. We request the 3 IR broad band filters to assess which is the most useful for accurate CMDs - trading off sensitivity and photometric accuracy and the structure of the resulting CMDs.

A number of ELT science cases assume that accurate photometry can be carried out at very faint levels over relatively wide fields of view. It is very important to test this assumption as far as possible with currently available facilities. A useful generally applicable case is the photometry of point sources in crowded stellar fields, which provide natural, accurate probes of photometric sensitivity and depth. AO currently only works at IR wavelengths and this is likely to remain the case for an ELT in the future and hence this necessitates adapting current analysis techniques, which are almost exclusively carried out at optical wavelengths. These changes bring several challenges to be able to interpret these new kinds of data sets and the first step is to gain useful *training* data sets. There are accurate and detailed CMDs of stellar systems with standard (single guide star) AO IR instrumentation (e.g., Diolaiti 2000 A&AS, 147, 335; Olsen et al. 2006 AJ, 132, 271) but this has so far been done with short integrations over tiny fields of view concentrating on IR bright stars, such as AGB and carbon stars. A coordinated effort needs to be made to define the requirements for accurate photometry of faint stars in crowded wide field images to understand the true sensitivity of AO systems for these kinds of studies.

Targets and integration time

Target	**RA**	**DEC**	**Filter**	**Magnitudes**	**Total integration time** (sec)	**Field** (arcmin)
NGC 371	01 03 13	-72 05 45	JHK	J=23; H=22.5; K=22	6.5hrs	1
NGC 1928	05 21 05	-69 27 38	JHK	J=23; H=22.5; K=22	6.5hrs	1

Guide stars list and positions

Target: NGC 371			
	$\mathbf{RA}''_{rel}$	$\mathbf{DEC}''_{rel}$	**V Mag**
GS1	-50	-30	9.6
GS2	-25	+40	11.2
GS3	+35	-55	11.4
GS4	+55	+60	11.3
Target: NGC 1928			
GS1	+15	-1	10.2
GS2	+50	+45	10.4
GS3	+55	-55	11.1

Time Justification:

The aim of this proposal is to get as deep as possible in a reasonable time for each of the filters. To get to old Main Sequence Turnoffs means J=23., H=22.5, K=22. (S/N$\sim$ 15) which means a total of about 2 hours telescope time per filter. Which means 6 hours of integration time for each pointing plus the overhead for field aquisition.

For NGC371 we would like to concentrate on a central field; and for NGC1978 we would like to get as close as possible to the field offset from the centre (-60, +60). The exact positioning is not critical, and the best position for correcting as large a field as possible as accurately as possible is preferred for both fields.