EUROPEAN ORGANISATION FOR ASTRONOMICAL RESEARCH IN THE SOUTHERN HEMISPHERE

Scientific Technical Committee
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For Recommendation

Science Evaluation of Hosted Telescope Proposals
QUEST2

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Scientific Technical Committee is invited to issue a recommendation to the Director General.
1. **Introduction**

Based on STC-545 all proposals for Hosted Telescopes are evaluated for their science value by a panel selected by the Directors for Science and Operations. The panel consisted of Kirsten Kraiberg Knudsen (STC), Bruno Leibundgut (ESO), Livia Origlia (STC) and Ivo Saviane (ESO). The evaluation considered the astrophysical impact of a proposal submitted to install and operate for five years a new version of the QUEST camera at the ESO Schmidt telescope on La Silla.

The *LSQ2: The Next-Generation La Silla QUEST2 Survey* was submitted by a consortium of institutions from the China, Chile, France, Germany, Spain, the United Kingdom, Italy, The Netherlands, Finland and the USA. It proposes to use the ESO 1m Schmidt telescope with a refurbished QUEST camera to search for transient objects.

The panel finds:

LSQ2 presents two focussed surveys, which are of high scientific value. The Type Ia supernova survey in the local volume provides an important basis to calibrate future cosmological measurements. The search for low surface brightness galaxies proposed in LSQ2 appears unique and may be even more interesting than the transient survey. The scientific potential of these surveys is regarded as high.

While the science evaluation is positive, there remain a number of technical concerns with the proposal. The proposal lacks clear schedules for the construction and deployment of the new LSQ2 camera. No specifics on the calibration plan, the data handling and the substantial efforts for data analysis are provided. The delivery schedule of the 2m telescope on Cerro Ventarrones appears optimistic.

The panel is positive about the proposed science to be achieved by the LSQ2 surveys. It recommends addressing the technical concerns in collaboration with ESO in the coming months.
2. **LSQ2: The Next-Generation La Silla QUEST2 Survey**

2.1 Science

The La Silla QUEST Southern Hemisphere Variability Survey (LSQ1; Baltay et al. 2012, The Messenger 150, 34) operated between 2009 and 2016. The ESO Schmidt telescope was equipped with a 160 Mpix prime-focus camera covering 10 deg$^2$ in a single exposure. The survey originally focussed on detecting Kuiper-Belt Objects (KBOs) and RR Lyrae stars and was later extended for supernova searches. It was an important survey to feed the Public ESO Spectroscopic Survey of Transient Objects (PESSTO, Smartt et al. 2015, A&A 579, A40), which ran from 2012 to 2017. During the first 3 years, La Silla QUEST provided 60% of the targets for PESSTO.

The *Next-Generation La Silla QUEST2 Survey* proposes to use a refurbished camera covering a field of view of 21 square degrees with state-of-the-art CCDs to perform two surveys over 5 years. A detailed study of Type Ia supernovae in the Hubble flow as the anchor to future, higher-redshift surveys like DES, LSST and PanSTARRS as well as space studies (*EUCLID* and *WFIRST*) for cosmology, and a search for low-surface brightness galaxies in the southern hemisphere.

Additional science cases include the use of core-collapse supernovae as distance indicators, follow-up observations of gravitational wave sources, RR Lyrae stars to map the structure of the Milky Way halo, variability studies of AGN and quasars and the search for strongly lensed quasar images, and tidal disruption events.

With 60-second exposures in two filters the survey plans to cover up to 4000 square degrees in one night and about 20000 square degrees per year with a 2-day cadence. Shorter exposures with more filters could also be considered. No trade-off study which operational mode is preferred is presented. Contrary to LSQ1 the quality of the CCDs would allow the project to obtain broad-band light curves that can be used for the photometric analysis. LSQ1 was a discovery machine, LSQ2 would provide the photometric data for the light curves. A 2m telescope operated by the Chinese Academy of Sciences to be installed on Cerro Ventarrones in 2020 will be used as spectroscopic follow-up facility to observe a large fraction of supernovae with a goal of six spectroscopic epochs per supernova. Once SOXS becomes operational (late 2021), it will be used to provide spectroscopic follow-up as well.

The transient survey competes with other similar searches. There are a number of past and current transient surveys to which LSQ2 should be compared. The main sources of local Type Ia supernovae come currently from the CfA survey, the Supernova Factory, the Palomar Transient Factory, LSQ1 and the Foundation Survey, which uses the PanSTARRS telescope. Each of these surveys has provided of the order of 300 Type Ia supernovae. In most cases there was only one spectrum per supernova observed to assure the correct classification. The exception is the Foundation Survey, which plans to discover 800 nearby Type Ia supernovae. Again, only a single spectrum for the classification is obtained. LSQ2 would distinguish itself by a more massive spectroscopic coverage, which is argued to provide a more secure classification also for sub-types of Type Ia supernovae and hence provide a cleaner sample for cosmology. Their aim is to obtain 800 to 1000 well observed and characterised local Type Ia supernovae. There are several transient surveys with smaller telescopes under way (ASASSN, OGLE, Catalina Ridge, SkyMapper, ALTAS) and planned (BlackGEM), but they are not focussed on the Type Ia supernovae like the proposed LSQ2. The cadence of the BlackGEM surveys will be of order weeks and they have no dedicated spectroscopic follow-up planned. Gaia provides interesting transient objects, but again at a cadence, which is much lower than the proposed LSQ2 surveys. However, Gaia has significant overlap with some parts of the additional transient surveys proposed in LSQ2. E.g. RR Lyrae, have been fully covered by Gaia already. However, no mention of Gaia is found in the proposal.
Low-brightness galaxies have recently become a hot topic again. The fast camera would allow LSQ2 to obtain deeper surface brightness limits than most other survey telescopes. The main competition is the Stromlo Milky Way Satellite Survey with SkyMapper, however that search focuses on finding resolved stellar populations rather than ultra-low surface brightness galaxies. LSQ2 claims to be the only such facility in the southern sky until LSST will provide similar sensitivities. To improve the sensitivity of this survey drift scanning is being considered.

2.2 Implementation and Operations

The LSQ2 proposal presents two focussed science cases (local Type Ia supernovae and low-surface brightness galaxies) and several additional transient science projects, which can be pursued with the survey data. While the science cases are considered interesting, the technical description is limited in several aspects. No implementation plans for the LSQ2 camera and the 2m telescope on Ventarrones are given. The required photometric accuracy for the transient survey and the flatfielding issues for the low-surface brightness survey are not discussed. The calibration requirements derived from the sought precision are not presented. The proposal is unclear how the time would be distributed between the two surveys. It was not possible to verify whether the two surveys can fit into the 5 year project duration and how the observations would be interlaced.

A brief section is devoted to a potential use of an objective prism for a survey, however no science case is presented. The panel suggests to drop the objective prism survey, if LSQ2 is implemented.

The follow-up facilities (SOXS and the 2m telescope on Ventarrones) would be available slightly later than the LSQ2 start but provide an important complement for the expected science gains. However, the schedule for the development of Ventarrones as a site are unclear and it would be important to have a reliable schedule presented for this important follow-up facility. A risk mitigation for the case that significant delays in deployment of the 2m telescope would have been useful. The proposed transient survey heavily relies on sufficient spectroscopic follow-up to be interesting.

The proposal also does not expand on the substantial data handling and analysis facilities needed for a successful survey. The team has relevant survey expertise, but the proposal does not specify how the data processing and interpretation will be distributed within the team.

The LSQ2 team (48 collaborators, 21 from ESO member states) is well balanced and contains the required expertise to perform the survey. The connection to SOXS is established through the SOXS Principle Investigator who is also an LSQ2 member.

The consortium proposes to cover all operational and hardware costs, including potential refurbishment of the Schmidt telescope and the dome.