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A NEW RR LYRAE SURVEY OF THE GALACTIC HALO USING QUEST COLLABORATION DATA

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RESUMEN

En este proyecto de tesis se propone un estudio de las subestructuras conocidas del halo Galáctico, así como el hallazgo de nuevas subestructuras a partir de datos procedentes de la colaboración QUEST. Se cree que tales subestructuras son remanentes de cúmulos globulares o galaxias enanas acrecionadas, similares a la galaxia esferoidal enana de Sagitario. Las estrellas RR Lyrae serán empleadas para trazar el halo debido a que son fácilmente detectables ya que constituyen excelentes luminarias estándar, cuyas distancias están mejor determinadas que trazadores alternativos, e.g. gigantes M. Parte del proyecto comprende la observación espectroscópica de estrellas RR Lyrae en la corriente generada por la galaxia enana de Sagitario a fin de determinar sus dimensiones espaciales, estructura, velocidad radial y velocidad de dispersión. Tales propiedades permiten restringir modelos de la corriente que contempla diferentes geometrías del halo de materia oscura.

ABSTRACT

This thesis project intends to study the known substructures in the galactic halo and search for new ones using data from the QUEST collaboration. These substructures are believed to be remnants of globular clusters or accreted dwarf galaxies, similar to the Sagittarius dwarf spheroidal galaxy. RR Lyrae stars will be used to trace the halo because they are relatively easy to detect and because they are excellent standard candles whose distances are better determined than alternative tracers,e.g., M giants. Part of the project involves spectroscopic observation of RR Lyrae stars in the leading stream from the Sgr dSph galaxy, which will better determine its spatial dimensions, structure, radial velocity and velocity dispersion. These properties constrain models of the stream that assume different shapes for the dark matter halo.

Key Words: **DARK MATTER — GALAXY: FORMATION — GALAXY: HALO — GALAXY: STRUCTURE — STARS: VARIABLES: OTHER**

1. THESIS PROJECT

This project will consist of a spectroscopic survey of a big part of the sky using RR Lyrae as tracers, data from both QUEST collaboration projects, QUEST1 and QUEST-Palomar, and using Chilean telescope time. Our goals are to find new halo streamers as well as to confirm and study in more detail previously detected ones. In particular, we will investigate the leading stream from the Sgr dSph galaxy and compare its properties with models of the stream that assume different shapes for the dark matter halo. RR Lyrae variables are excellent standard candles, and are relatively easy to select in terms of variability, taking advantage of the fact that both QUEST projects do repeated scans of different areas of the sky. RR Lyrae are also old and as such able to trace older passages of the Sgr stream and be sensitive to halo shape, which is not the case with younger tracers.

1.1. *QUEST Collaboration Data*

The QUEST collaboration uses two CCD mosaic arrays, QUEST1 and Quest-Palomar. QUEST1 uses a 1 meter telescope and a 4×4 CCD array and QUEST-Palomar uses a 1.25 meter telescope and a 28×4 CCD array, the largest and latest CCD mosaic array. By comparison, our closest competitor is the Sloan Digital Sky Survey (SDSS), which uses a 2.5 meter telescope and a 6×5 CCD array. The most important difference between QUEST1 and both QUEST-Palomar and SDSS is that QUEST1 produces not only RR Lyrae candidates but confirmed RR Lyrae stars because from its many epochs of repeated observations the light curves and periods of the variables can be accurately determined. It is important to stress that at this point the number of repetitions of observations of a particular area of the sky is far superior in QUEST1 than in both QUEST-Palomar and SDSS. We expect that QUEST-Palomar will provide several epochs of observations, but probably not as many needed for de-

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termining periods. Nonetheless, it will provide adequate observations for detecting RR Lyrae stars by their variability. The distinctive characteristic of the SDSS as a competitor is that it goes deeper into the halo ($R \sim 21.5$ mag) than both QUEST1 ($R \sim 19.5$ mag) and QUEST-Palomar ($R \sim 20.5$ mag). QUEST-Palomar is an improvement from QUEST1 but it is not as deep as SDSS. Both SDSS and QUEST-Palomar will eventually be complementary because they cover different areas on the sky.

We already know that QUEST1 is able to find over-densities by means of RR Lyrae search (Vivas & Zinn 2004; Vivas 2001; Zinn et al. 2003). The main overdensities found on the first strip of data from QUEST1 (the one centered at DEC $= -1°$ covering 380 squared degrees) are: the biggest one related to the Sgr dwarf and two others, one related to the disruption of the globular cluster Pal 5 and another one referred as the 12.4 hr over-density.

Using data from QUEST1, we will observe spectroscopically the faint RR Lyrae stars in the Sgr leading stream. These observations will be compared with the M giant stars in this stream, which are much younger than the RR Lyrae variables. We will obtain radial velocities and metallicities and continue to the next strip of the QUEST1 project, centered at DEC $= -3°$.

With data obtained from QUEST-Palomar, we will develop a selection pipeline for RR Lyrae, search for over-densities, do the spectroscopic follow-up and obtain radial velocities and metallicities. QUEST-Palomar's main appeal is the large area that covers from DEC $=-24°$ to DEC $= +24°$. This will allow tracing of any possible structure over many square degrees. QUEST-Palomar also goes a magnitude deeper than QUEST1, greatly increasing the volume searched for structures.

1.2. *Motivation of the project*

The spectroscopic follow up of the QUEST1 faintest feature, the Sgr dwarf stream is already an ongoing project. Vivas and collaborators already studied 16 targets (Vivas et al. 2004). With our VLT, Gemini and Magellan proposals will study further the Sgr stream, in particular to assess whether it extends even more in RA as already suggested by Vivas' thesis (Vivas 2002). We will study the extent and width of this feature, the leading arm of the Sgr dwarf. We will confirm not only the location of the stream on the sky, but also its distance and radial velocity dispersion. These properties can be compared with models of the stream, which are sensitive to the assumed shape of the dark matter halo. Therefore, the spectroscopic observations of the RR Lyrae stars in the stream may constrain the shape of this halo.

2. CONCLUSIONS

The advantages of this project are: proven experience from QUEST1, data already available and targets already selected and proposed for spectroscopic follow up. Projects have already been approved by Magellan in visitor mode and both Gemini South and VLT in service mode. The challenges are: the complexity of the new pipeline in the case of QUEST-Palomar, the calibration of QUEST-Palomar data that is still undergoing, and the managing of the great amounts of data that any of the QUEST collaboration projects produces. The impetuses provided by the availability of the QUEST data and generous awarding of telescope time (through the Chilean 10% share) will contribute to achieve our goals.

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