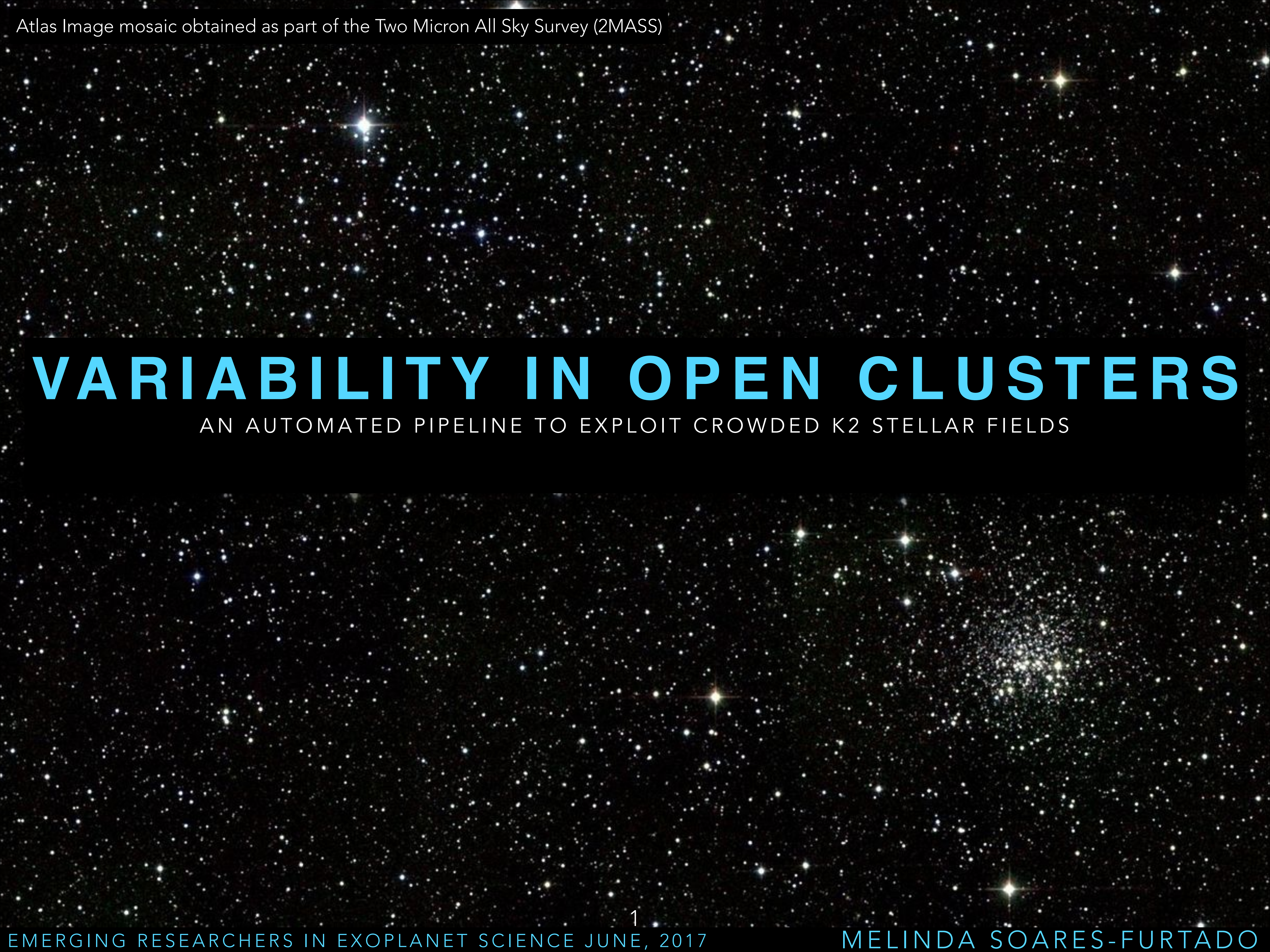


Atlas Image mosaic obtained as part of the Two Micron All Sky Survey (2MASS)

VARIABILITY IN OPEN CLUSTERS

AN AUTOMATED PIPELINE TO EXPLOIT CROWDED K2 STELLAR FIELDS

EMERGING RESEARCHERS IN EXOPLANET SCIENCE JUNE, 2017

MELINDA SOARES-FURTADO

OUTLINE

1. The Value of Variability Searches in Open Clusters

2. K2 Data Set

3. Our Image Subtraction Reduction Pipeline

4. Promising Results

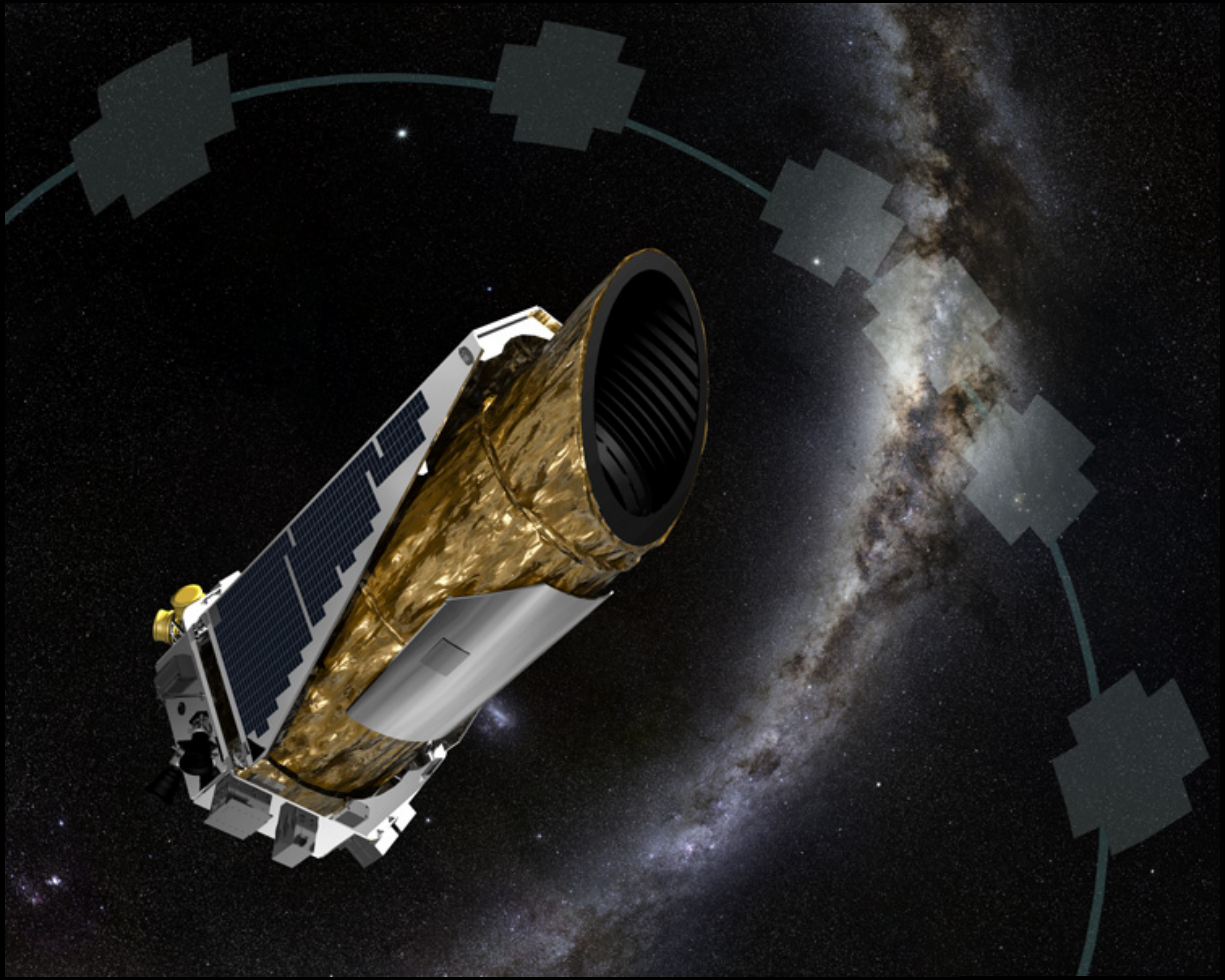
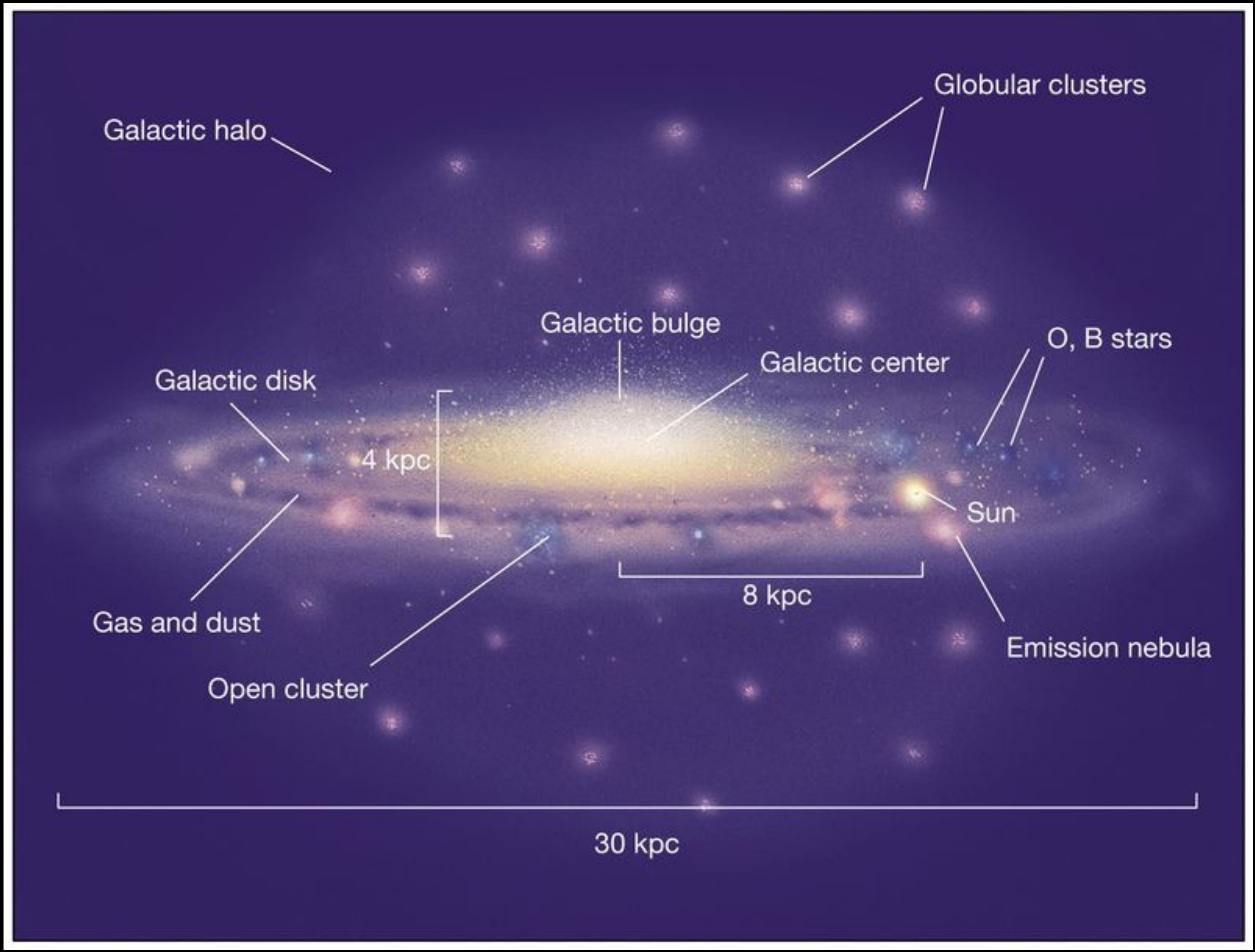


Image Credit: NASA

OPEN CLUSTERS IN THE MILKY WAY

1100

Credit: ESO/J. Borissova


Globular clusters
Galactic halo
Galactic bulge
O, B stars
Galactic center
Galactic disk
4 kpc
Sun
8 kpc
Gas and dust
Emission nebula
Open cluster
30 kpc

OPEN QUESTIONS

Do planets form around stars in open clusters with the same occurrence rate?

OPEN QUESTIONS

Do planets form around stars in open clusters with the same occurrence rate?

Are the planets within open clusters characteristically similar to non cluster members?

Search for giant planets in M67 III: excess of hot Jupiters in dense open clusters. ⋆

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Received / Accepted

ABSTRACT

Since 2008 we used high-precision radial velocity (RV) measurements obtained with different telescopes to detect signatures of massive planets around main-sequence and evolved stars of the open cluster (OC) M67. We aimed to perform a long-term study on giant planet formation in open clusters and determine how this formation depends on stellar mass and chemical composition.
A new hot Jupiter (HJ) around the main-sequence star YBP401 is reported in this work. An update of the RV measurements for the two HJ host-stars YBP1194 and YBP1514 is also discussed. Our sample of 66 main-sequence and turnoff stars includes 3 HJs, which indicates a high rate of HJs in this cluster ($5.6^{+5.4}_{-2.6}\%$ for single stars and $4.5\%^{+4.5}_{-2.5}\%$ for the full sample). This rate is much higher than what has been discovered in the field, either with RV surveys or by transits. High metallicity is not a cause for the excess of HJs in M67, nor can the excess be attributed to high stellar masses. When combining this rate with the non-zero eccentricity of the orbits, our results are qualitatively consistent with a HJ formation scenario dominated by strong encounters with other stars or binary companions and subsequent planet-planet scattering, as predicted by N-body simulations.

K2 Campaigns

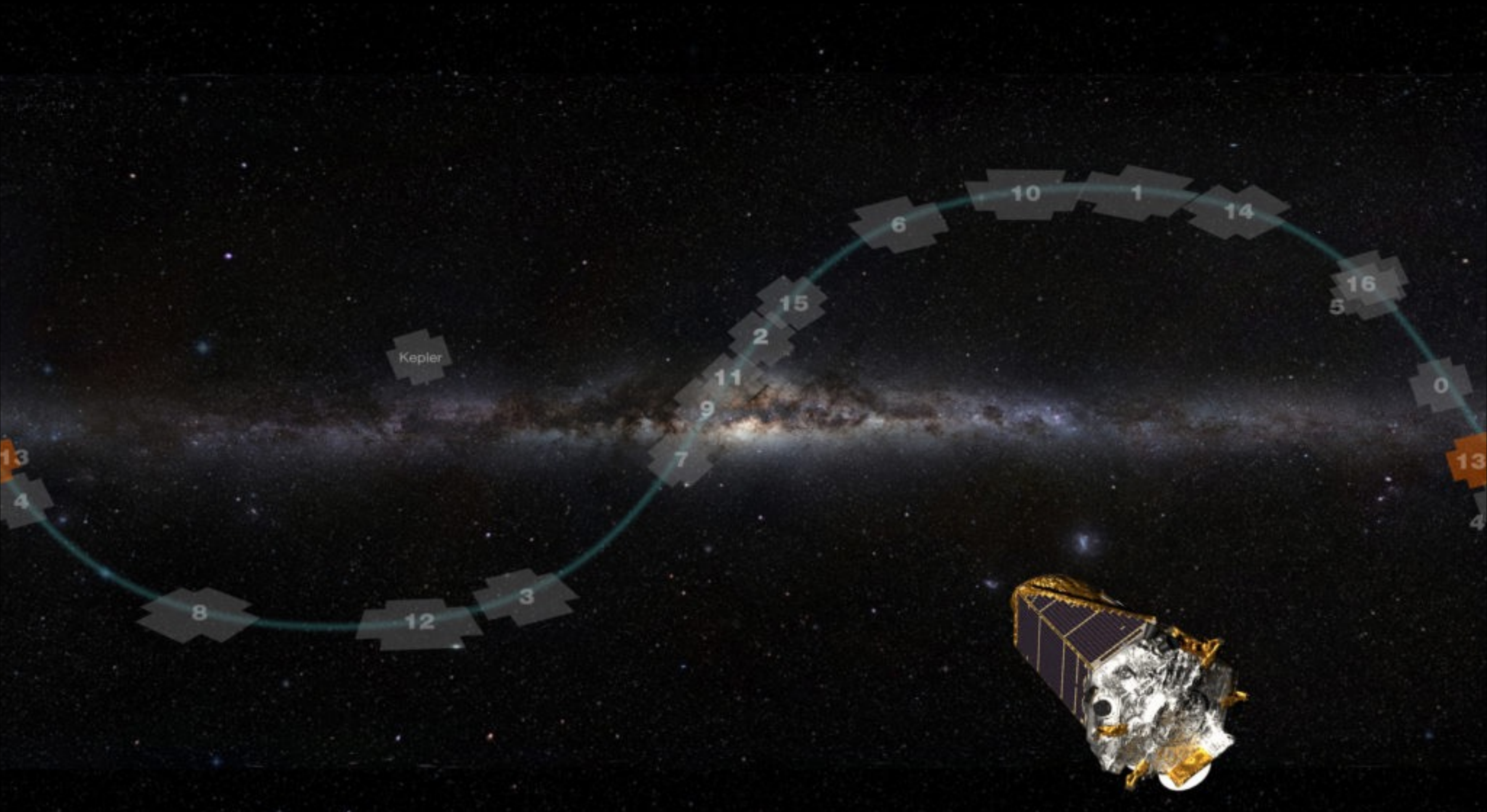
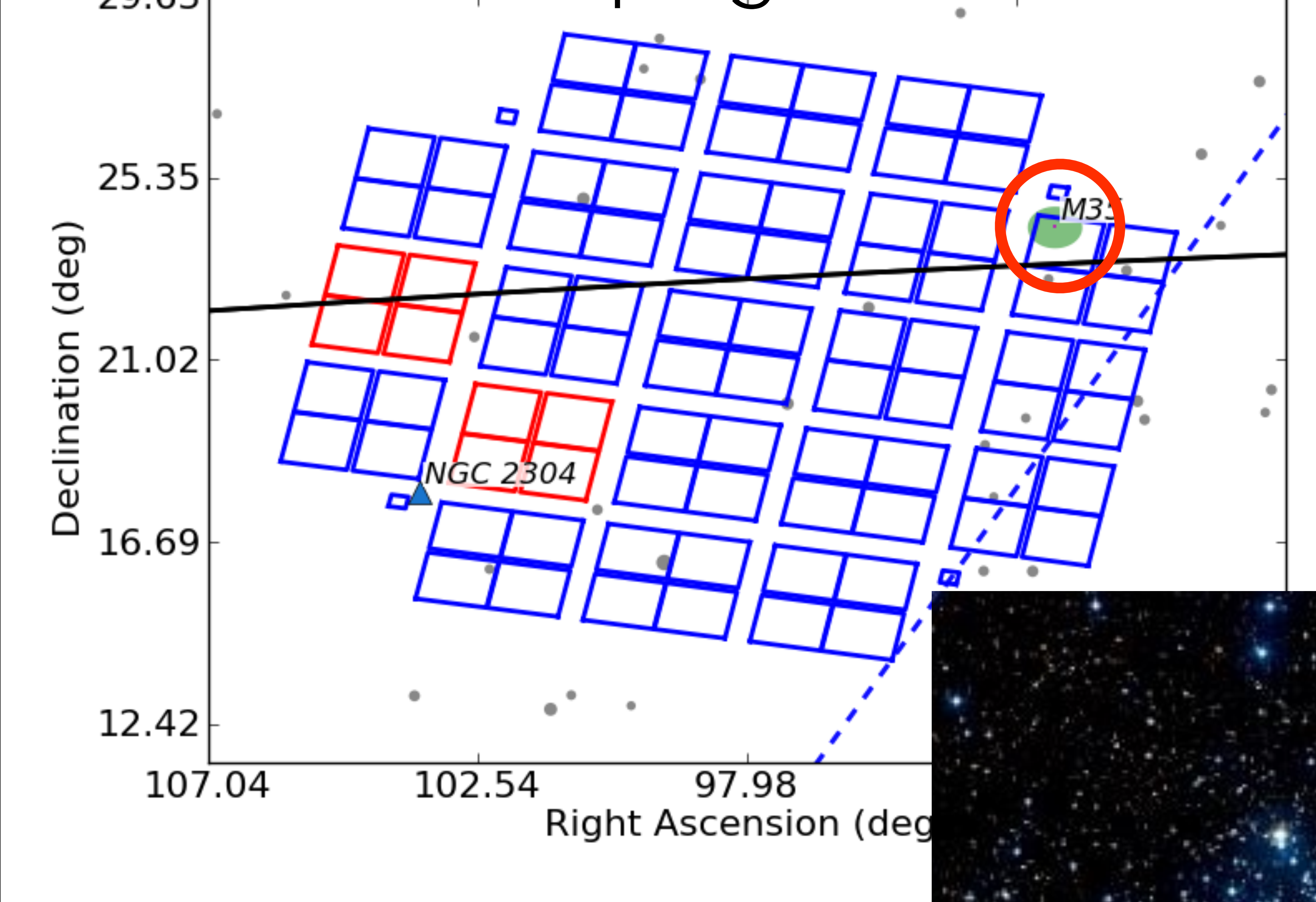


Image Credit: NASA

Campaign 0



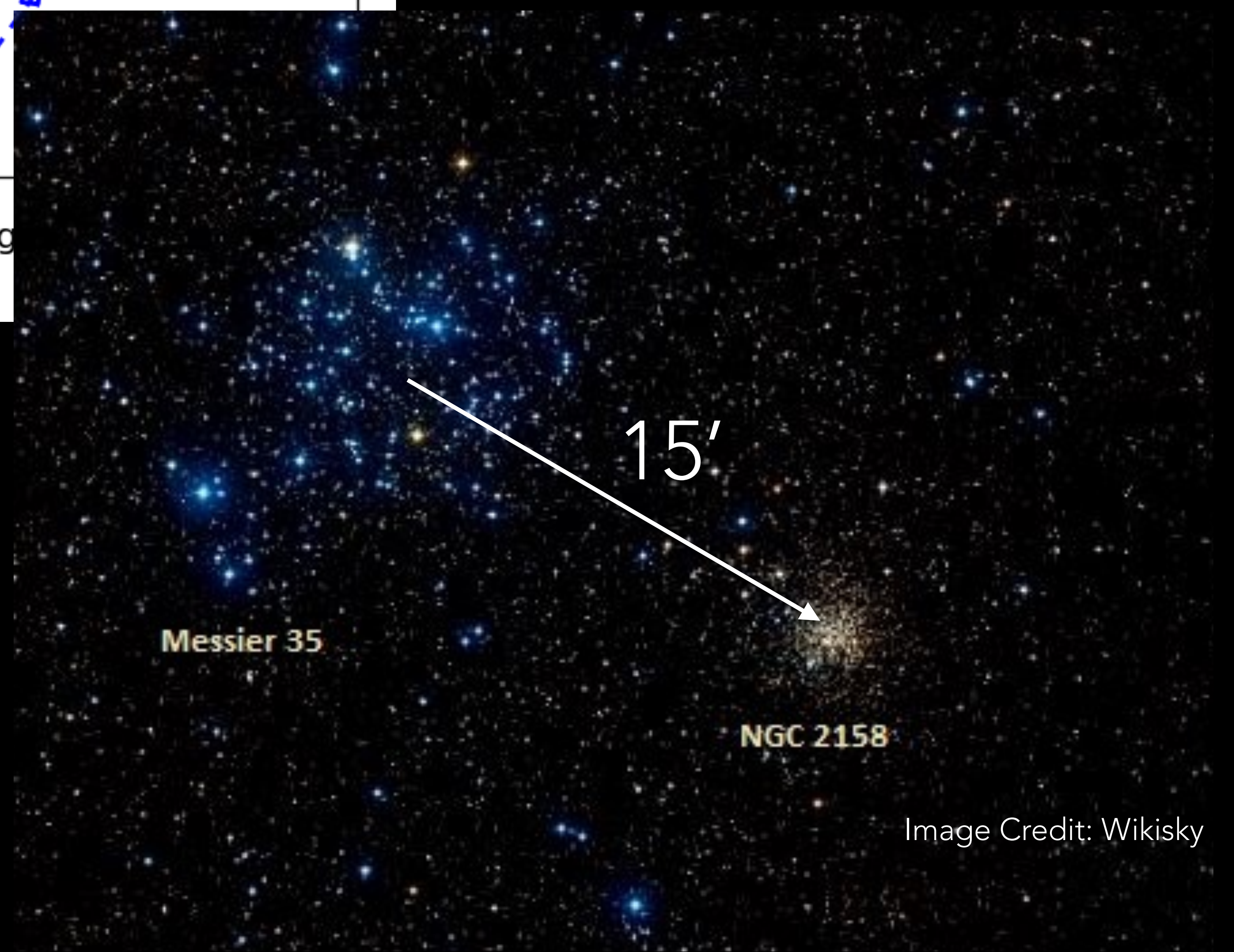


Image Credit: Wikisky

IMAGE SUBTRACTION PIPELINE

1. Acquire Raw Data
2. Stitch Raw Data
3. Translate Frames
4. Stack Master Frame
5. Subtract Master Frame
6. Perform Photometry on Subtracted Frames
7. Detrend and Assemble Light Curves
8. Search for Variability!

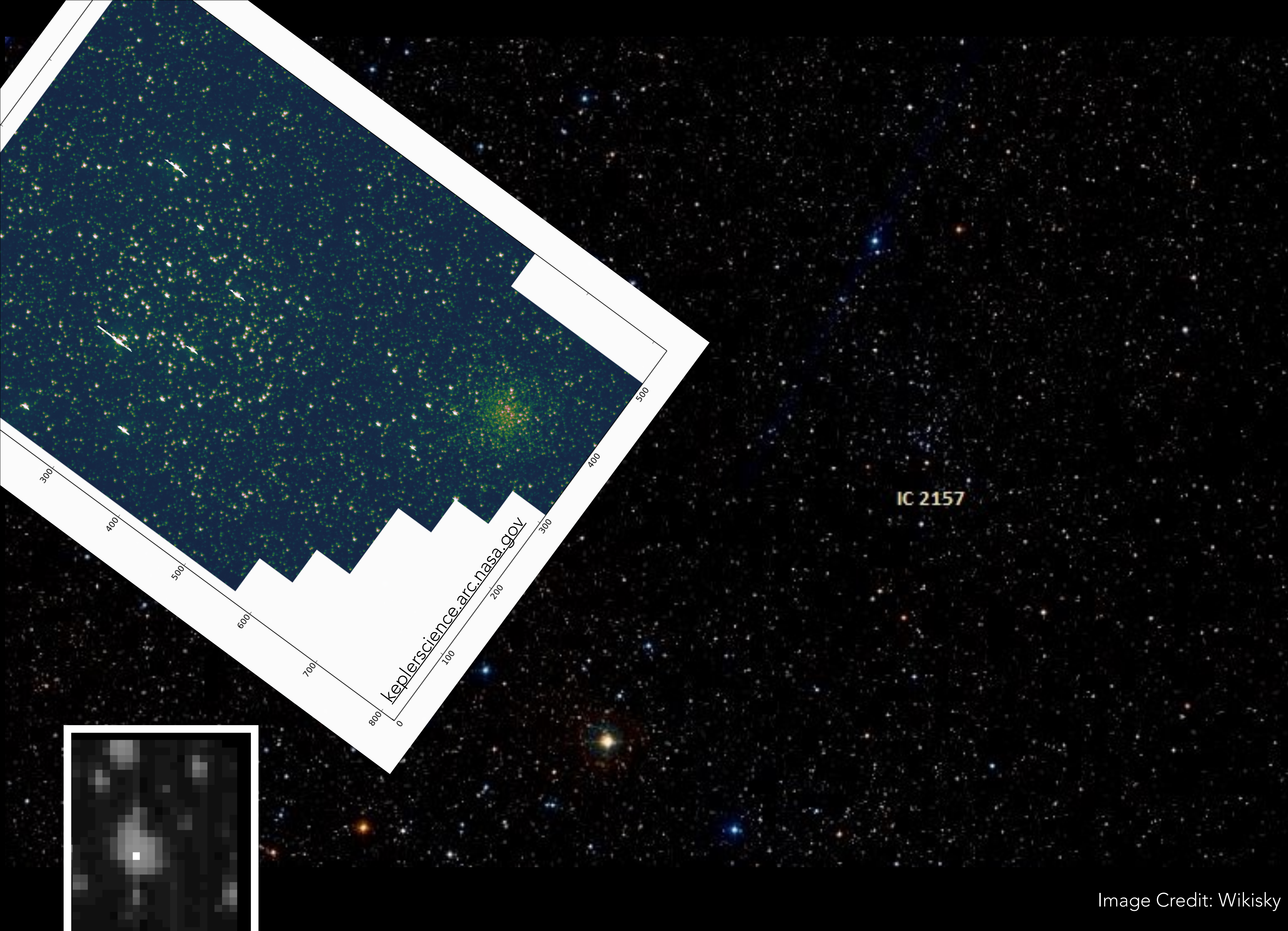
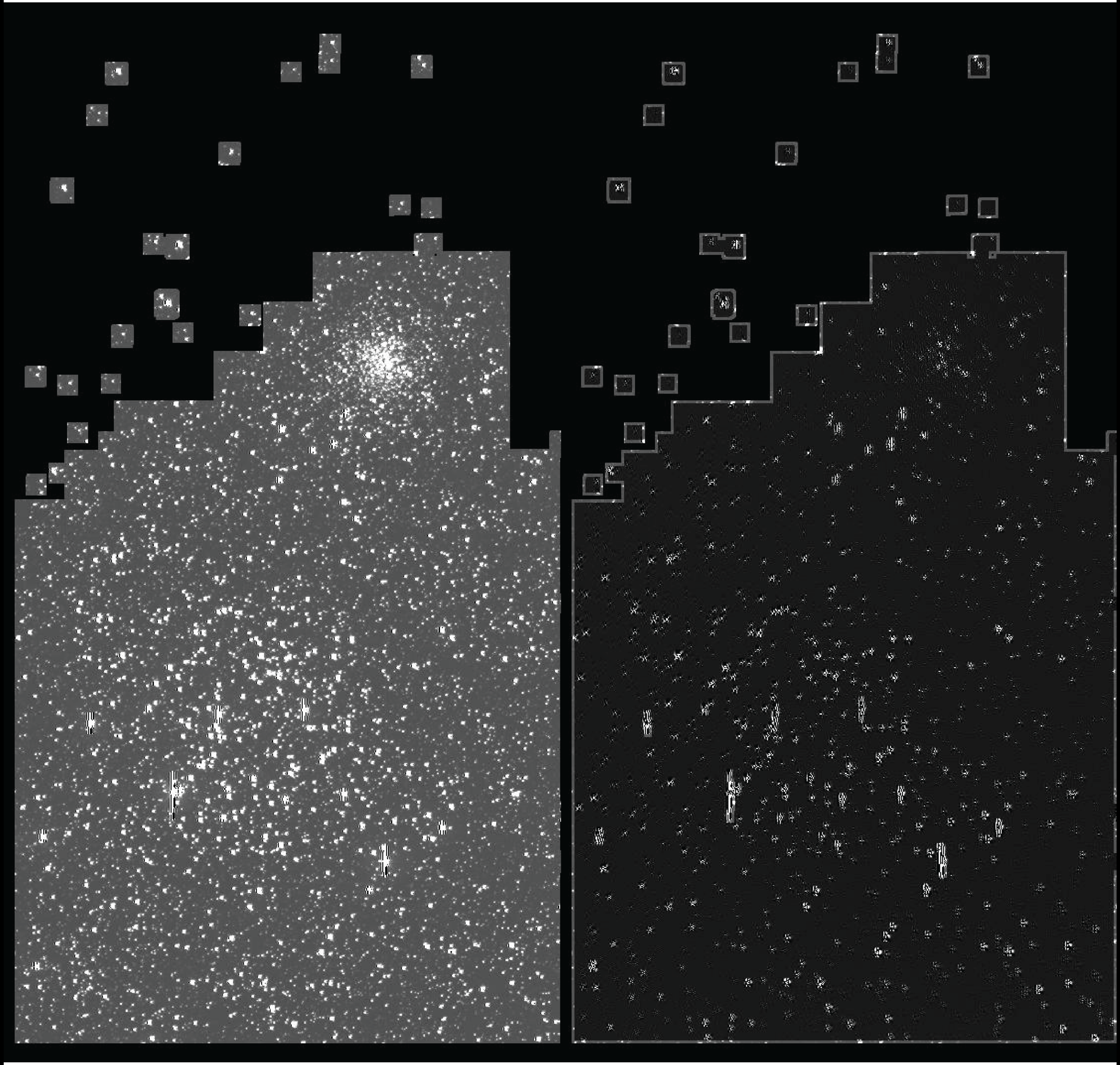


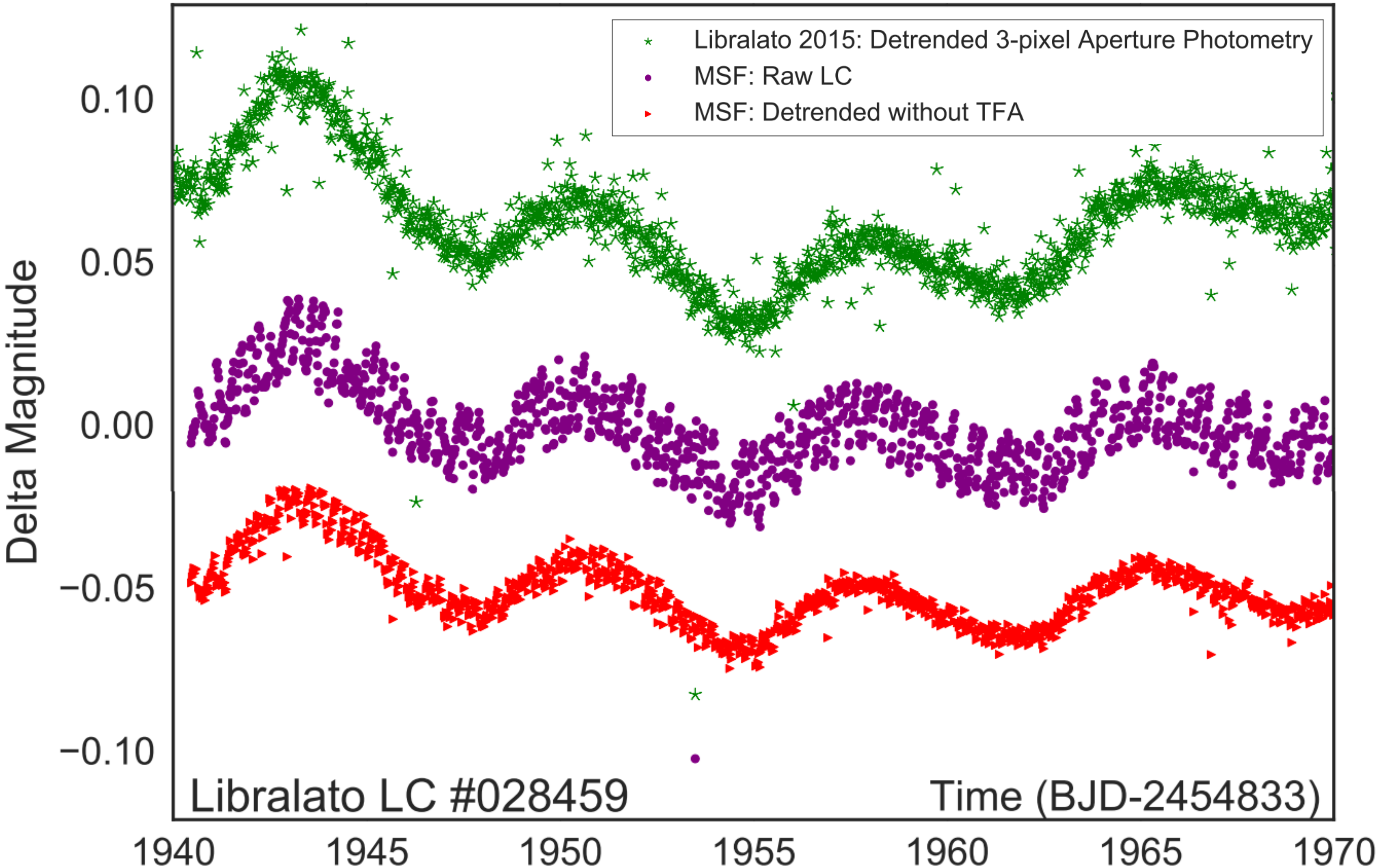
Image Credit: Wikisky

K2 Field 0 (Containing Open Cluster M35)



Unsubtracted Image | Subtracted Image

RESULTING LIGHT CURVES



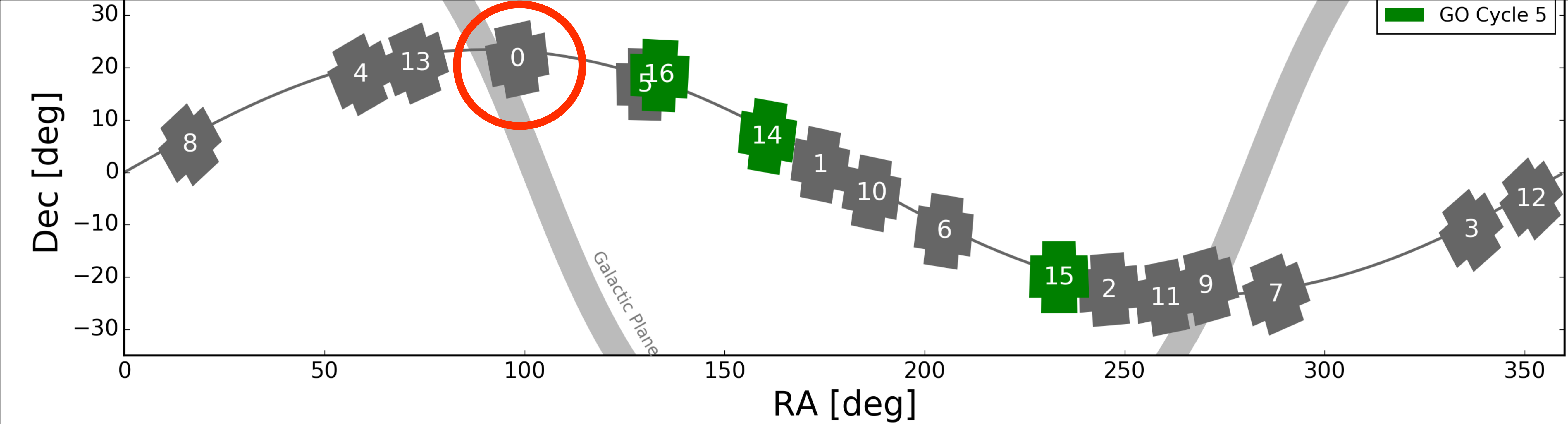


IMAGE SUBTRACTION REDUCTION OF OPEN CLUSTERS M35 & NGC 2158 IN THE *K2* CAMPAIGN-0 SUPER-STAMP

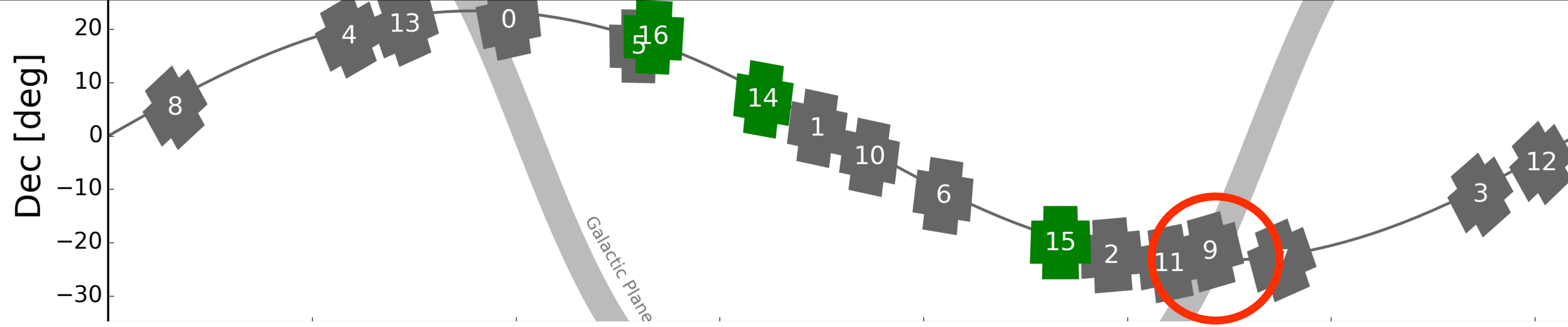
M. Soares-Furtado[1,†], J. D. Hartman[1], G. Á. Bakos[1,*,**], C. X. Huang[2], K. Penev[1], W. Bhatti[1]

Draft version March 2, 2017

ABSTRACT

Observations were made of the open clusters M35 and NGC 2158 during the initial *K2* campaign (C0). Reducing these data to high-precision photometric time-series is challenging due to the wide point spread function (PSF) and the blending of stellar light in such dense regions. We developed an image-subtraction-based *K2* reduction pipeline that is applicable to both crowded and sparse stellar fields. We applied our pipeline to the data-rich C0 *K2* super-stamp, containing the two open clusters, as well as to the neighboring postage stamps. In this paper, we present our image subtraction reduction pipeline and demonstrate that this technique achieves ultra-high photometric precision for sources in the C0 super-stamp. We extract the raw light curves of 3960 stars taken from the UCAC4 and EPIC catalogs and de-trend them for systematic effects. We compare our photometric results with the prior reductions published in the literature. For detrended, TFA-corrected sources in the 12–12.25 K_p magnitude range, we achieve a best 6.5 hour window running rms of 35 ppm, falling to 100 ppm for fainter stars in the 14–14.25 K_p magnitude range. For stars with $K_p > 14$, our detrended and 6.5 hour binned light curves achieve the highest photometric precision. Moreover, all our TFA-corrected sources have higher precision on all timescales investigated. This work represents the first published image subtraction analysis of a *K2* super-stamp. This method will be particularly useful for analyzing the Galactic bulge observations carried out during *K2* campaign 9. The raw light curves and the final results of our detrending processes are publicly available at `http://k2.hatsurveys.org/archive/`.

Subject headings: open clusters and associations: individual (M35), (NGC 2158) — stars: variables: general — methods: data analysis – techniques: image processing, photometric -surveys -astrometry / K2



EXTRACTING MICROLENSING SIGNALS FROM *K2* CAMPAIGN 9

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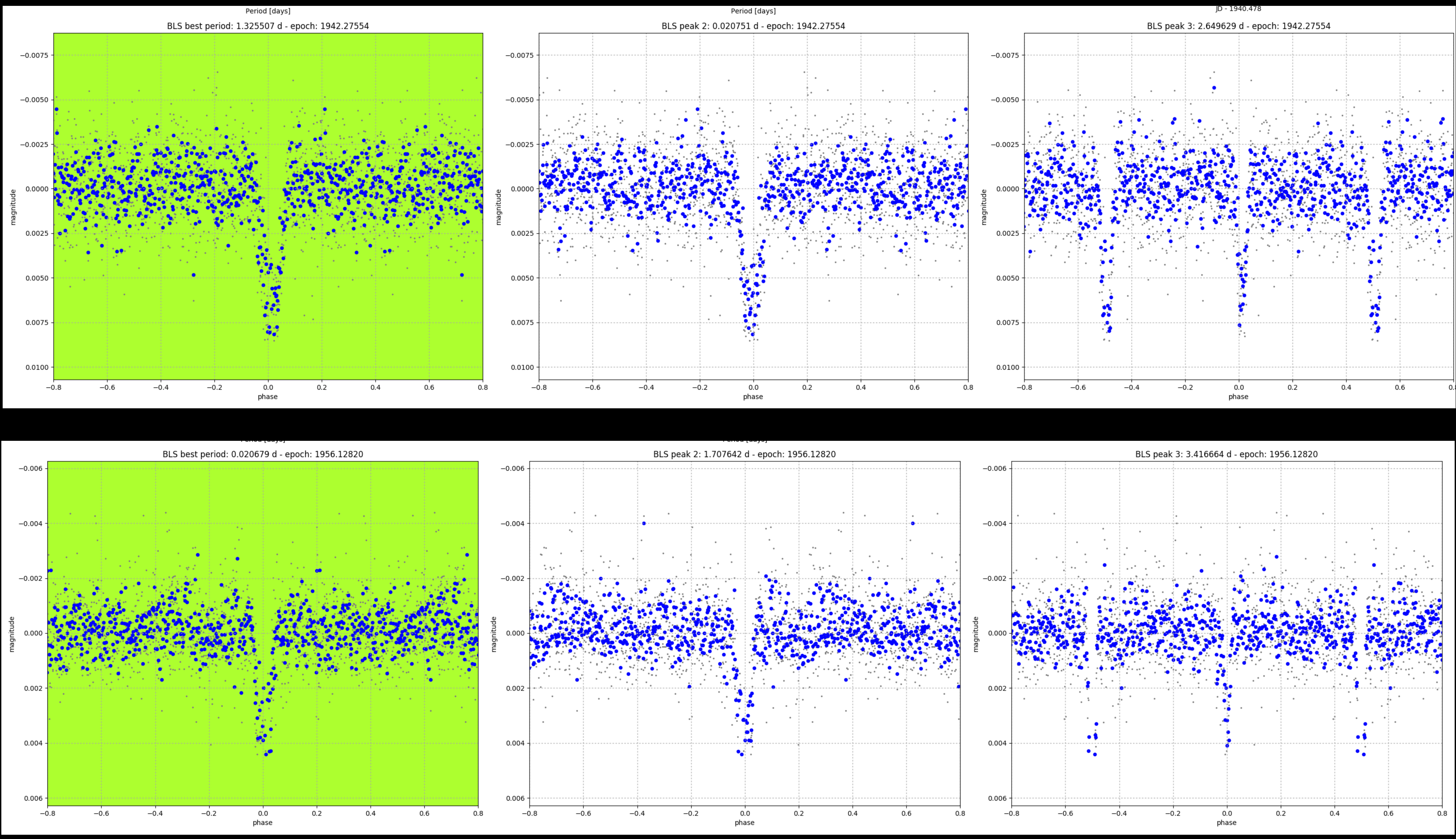
ABSTRACT

The reduction of the *K2*'s Campaign 9 (*K2*C9) microlensing data is challenging mostly because of the very crowded field and the unstable pointing of the spacecraft. In this work, we present the first method that can extract microlensing signals from this *K2*C9 data product. The raw light curves and the astrometric solutions are first derived, using the techniques from Soares-Furtado et al. and Huang et al. for *K2* dense field photometry. We then minimize and remove the systematic effect by performing simultaneous modeling with the microlensing signal. We also derive precise $(K_p - I)$ vs. $(V - I)$ color-color relations that can predict the microlensing source flux in the *Kepler* bandpass. By implementing the color-color relation in the light curve modeling, we show that the microlensing parameters can be better constrained. In the end, we use two example microlensing events, OGLE-2016-BLG-0980 and OGLE-2016-BLG-0940, to test our method.

PROMISING EXOPLANET SOURCES!



https://github.com/waqasbhatti/astrobase

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HTTP://K2.HATSURVEYS.ORG/ARCHIVE/