Ruprecht 147 – What's new with the oldest nearby star cluster

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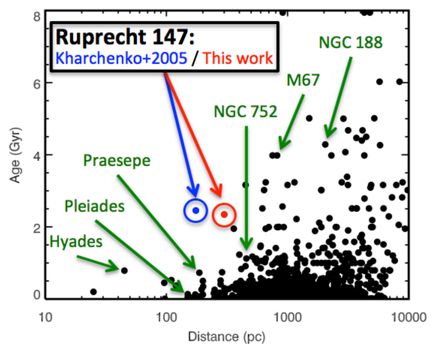
in collaboration with Adam Kraus, Ivan Ramirez and Steve Saar

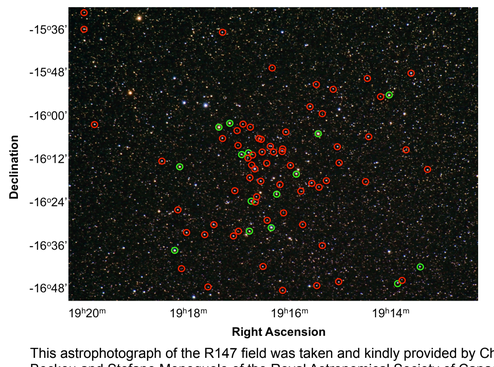
Summary: Ruprecht 147 is a hitherto unappreciated open cluster that holds great promise as a standard in fundamental stellar astrophysics. We have conducted a radial velocity survey of astrometric candidates with Lick, Palomar, and MMT observatories and have identified over 100 members, including 5 blue stragglers, 11 red giants, and 8 double-lined spectroscopic binaries (SB2s). We estimate the cluster metallicity from spectroscopic analysis, using Spectroscopy Made Easy (SME), and find it to be [M/H] = +0.07 ± 0.03. We have obtained deep CFHT/MegaCam g′r′i′z′ photometry and fit Padova isochrones to the (g′ – i′) and 2MASS ($J - K_S$) CMDs, using the τ^2 maximum-likelihood procedure of Naylor et al. (2009), and an alternative method using 2D cross-correlations developed in Curtis et al. (2012). We find best fits for isochrones at age t = 2.5 ± 0.25 Gyr, m – M = 7.35 ± 0.1, and A_V = 0.25 ± 0.05, with additional uncertainty from the unresolved binary population and possibility of differential extinction across this large cluster. The inferred age is heavily dependent by our choice of stellar evolution model: fitting Dartmouth and PARSEC models yield age parameters of 3 Gyr and 3.25 Gyr respectively. At ~300 pc and ~3 Gyr, Ruprecht 147 is by far the oldest nearby star cluster.

An Old Cluster, A New Benchmark

- With a distance of 300 pc and an age of 3 Gyr, Ruprecht 147 is the oldest nearby star cluster
- White dwarfs, M dwarfs, coronal X-rays (and hopefully rotation periods) are accessible
- R147 fills an important age gap between the young nearby clusters (e.g. Pleiades, Praesepe, Hyades) and the older Sun and more distant M67



Open cluster data from WEBDA

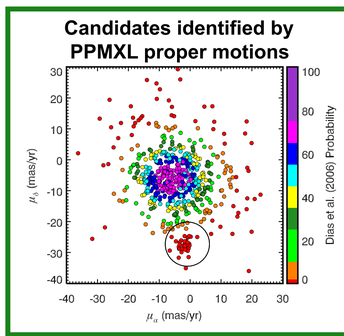


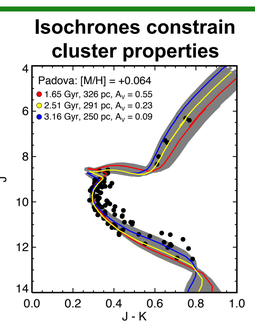
This astrophotograph of the R147 field was taken and kindly provided by Chris Beckeu and Stefano Meneguolo of the Royal Astronomical Society of Canada.

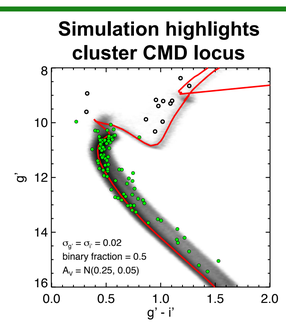
First R147 paper accepted to *AJ*

Ruprecht 147: A Close, Old Open Cluster as a New Benchmark in Stellar Evolution
by Jason L. Curtis, Angie Wolfgang, Jason T. Wright, John Brewer, and John Johnson

- We identified over 100 members from proper motions, radial velocities, and photometry
- We measured the cluster composition with Keck/HIRES spectra and Spectroscopy Made Easy (SME)
- We determined the cluster's isochrone age, distance and visual extinction from isochrone fitting, using Dartmouth, Padova and PARSEC models
- Please see the paper for our acknowledgements. Paper draft can be found at **arXiv:1206.6533**

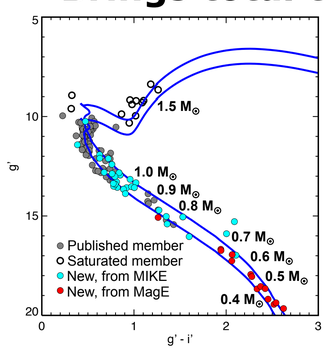


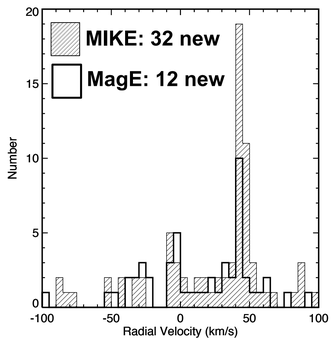




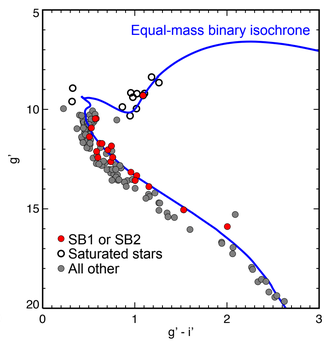
Magellan member survey

Brings total to 150 members



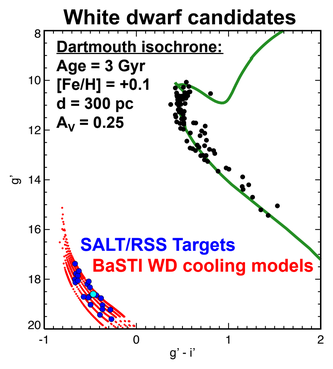


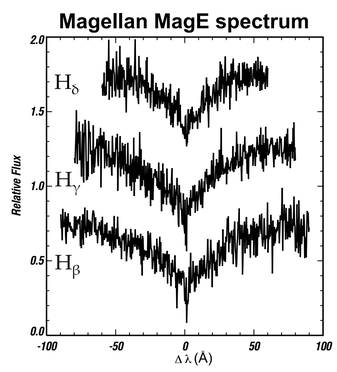
Binaries



Magellan RV Survey	• Targets selected from PPMXL proper motions, optical and NIR photometry • Observed 75 targets with MIKE at R = 40k and 50 targets with MagE
Still more candidates!	• Many stars were not observed due to weather complications • We will measure proper motions "soon" – should yield more candidates
Binaries discovered	• SB1s show variation between MIKE 2012 and MMT/Hectochelle 2010 RVs • SB1s and SB2s are found near equal-mass binary isochrone

Hunting for White Dwarfs

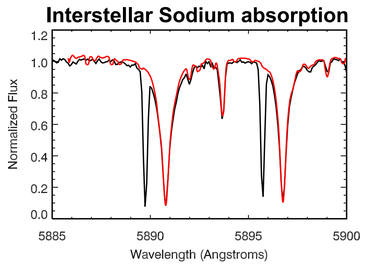




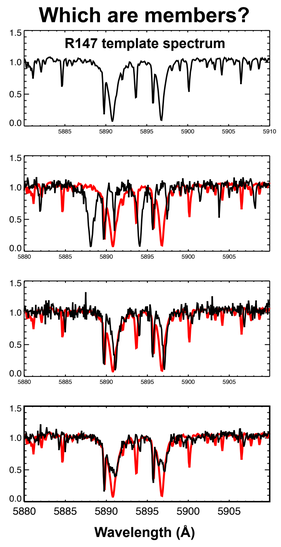
Identifying WDs is difficult	• Candidates are faint, in a dense field, and lack reliable proper motions • In the future, we'll re-image the field and derive proper motions
Science Goals	• Initial – Final mass relation data points • Age information independent of main sequence turnoff fitting
SALT/RSS Campaign	• 14 hours awarded to take R~4k spectra of WD candidates • Observations will hopefully commence in April 2013

The utility of interstellar Sodium

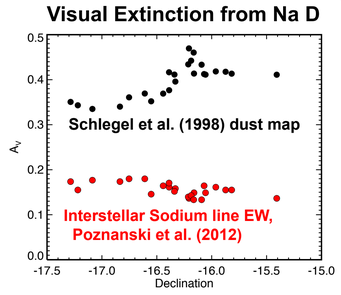
Interstellar Sodium absorption



Which are members?



Visual Extinction from Na D



Radial Velocities by eye

- When surveying for members at low signal-to noise, calculate "velocities" on the fly by checking relative positions of stellar and interstellar Na D sodium lines
- Useful for vetting candidates for follow-up at high S/N
- Also fun to know you haven't "wasted" an evening hunting for new members

Differential extinction?

- Assume Na D absorption traces A_V
- Remove stellar Na D lines
- Calculate equivalent width
- Use Poznanski et al. (2012) relation
  → visual extinction!
- Absolute value might be unreliable…
- …no evidence for differential extinction

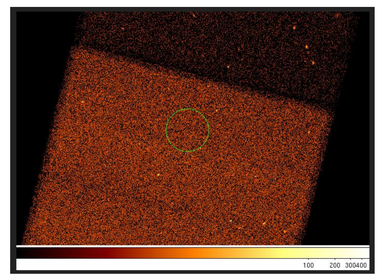
Upcoming Science with R147

My Plans

Magnetic Activity:
- Chromospheric activity – Ca II H & K and H_α
- Coronal X-ray (L_X) – *Chandra* observations complete!)

Stellar properties and composition:
- Analysis of 30 members with R= 40-65k, S/N = 150 – 250

Proper motion survey:
- Re-image R147 with CFHT/MegaCam in one year



Interested in working with Ruprecht 147? Let me know!

- **Loads of currently unpublished data:**
  (deep optical and NIR photometry, low and high resolution spectroscopy)
- **Over 40 new members**
- **Updated membership probabilities**

Email Jason Curtis at jcurtis@psu.edu

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