

Questions and Quandaries from the White Dwarfs

Found in the Sloan Digital Sky Survey

- Unusual Spectra: Implications for Convective Mixing, Diffusion, Accretion and Other Atmospheric Physics
- Constructing a Luminosity Function
- The Mass Distribution

James Liebert -- Univ. of Arizona and KITP

Many Coauthors will be named for various projects

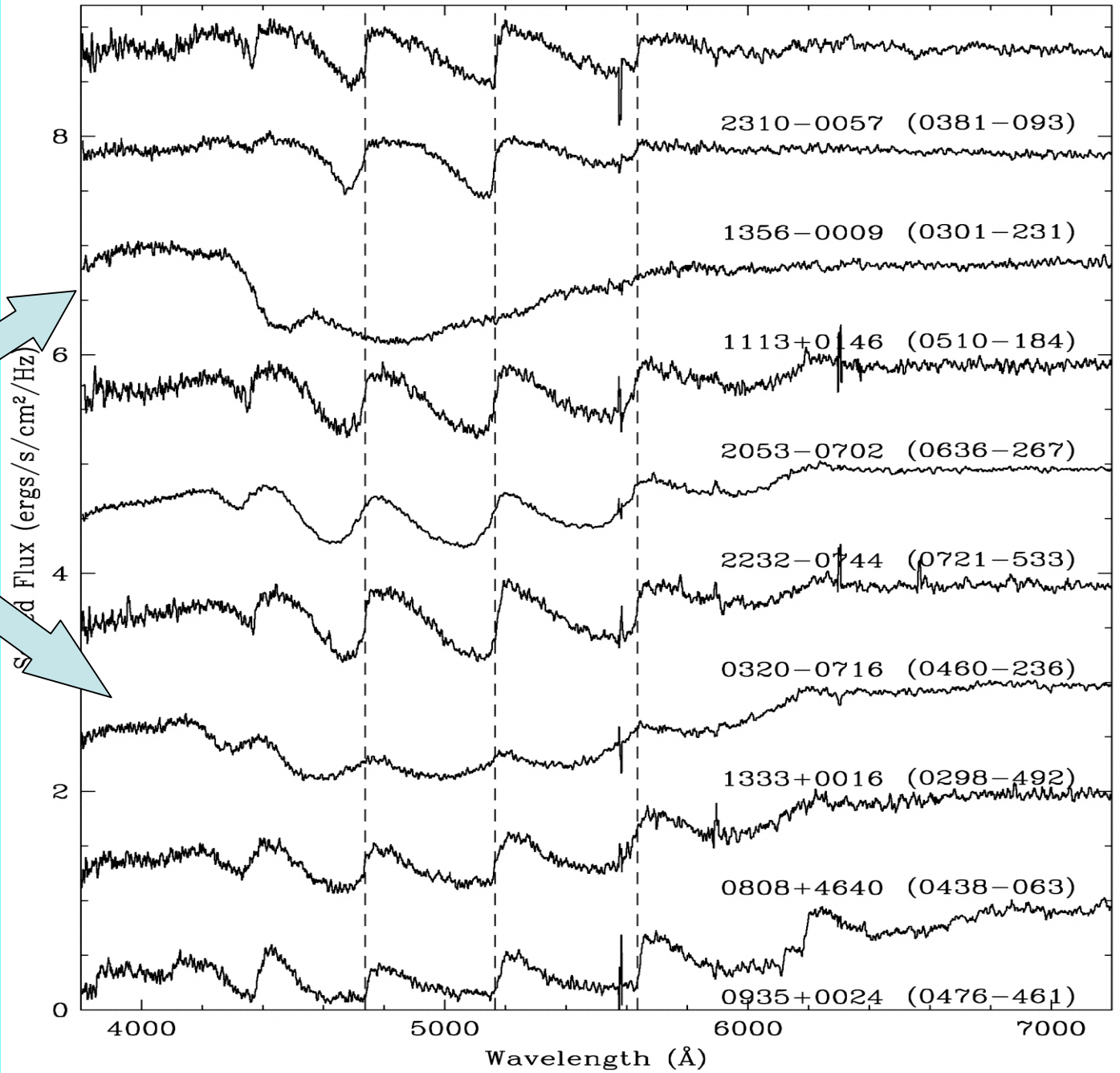
.as we go along ...

Cool

...and peculiar

DQ Stars

Some are
Magnetic



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LHS 2534

Rediscovered in SDSS

Zeeman 1897, ApJ, 5, 332

First found the Z effect in a
Flame of Sodium Gas

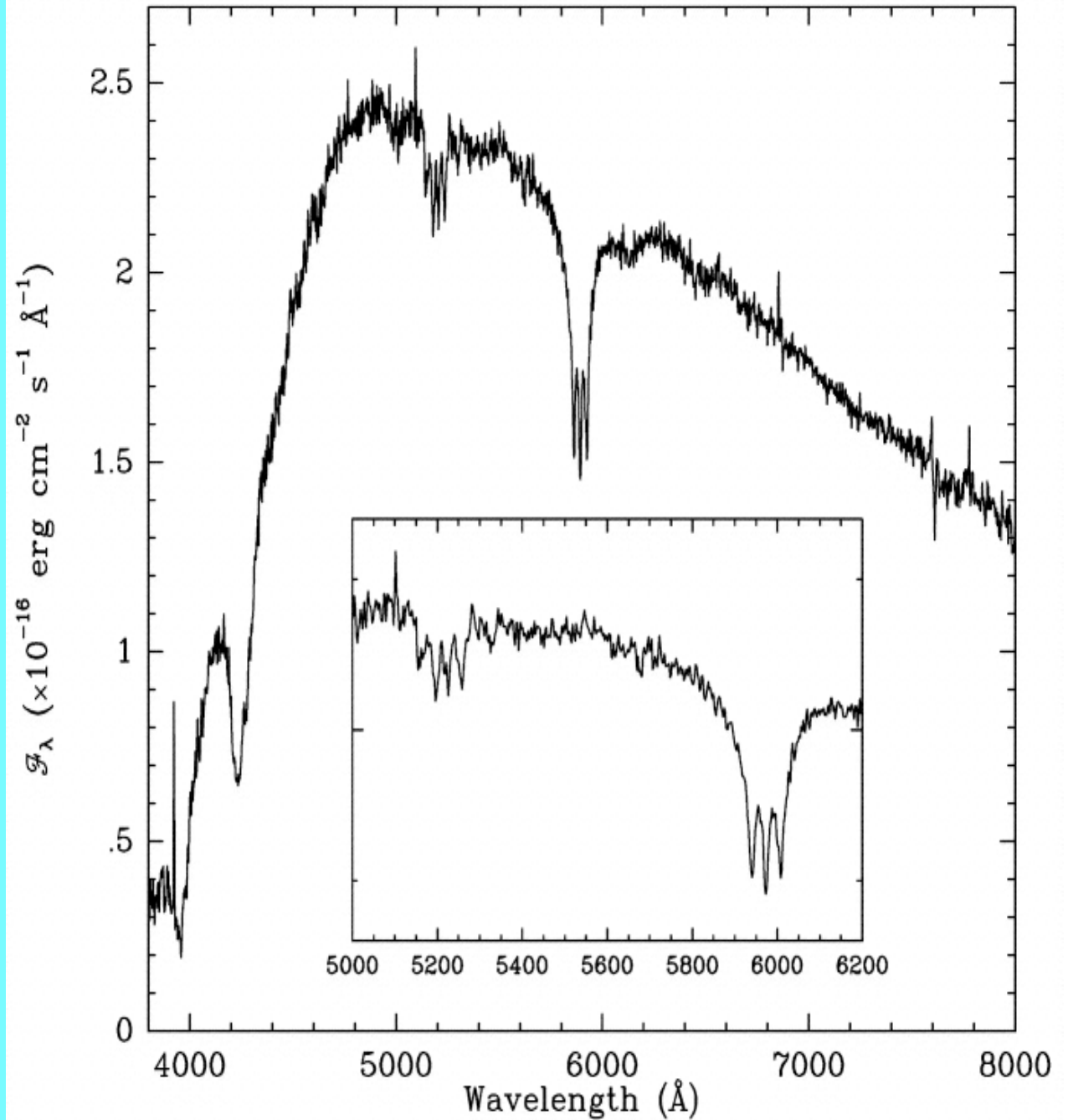
Na I 5889,5895Å

Mg I 5175Å triplet
Shows five components

Ca II 3933,3968Å
Should split into 5 lines

Reid, Liebert, and Schmidt 2001.
ApJ, 550, 61

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DA
50,000 K

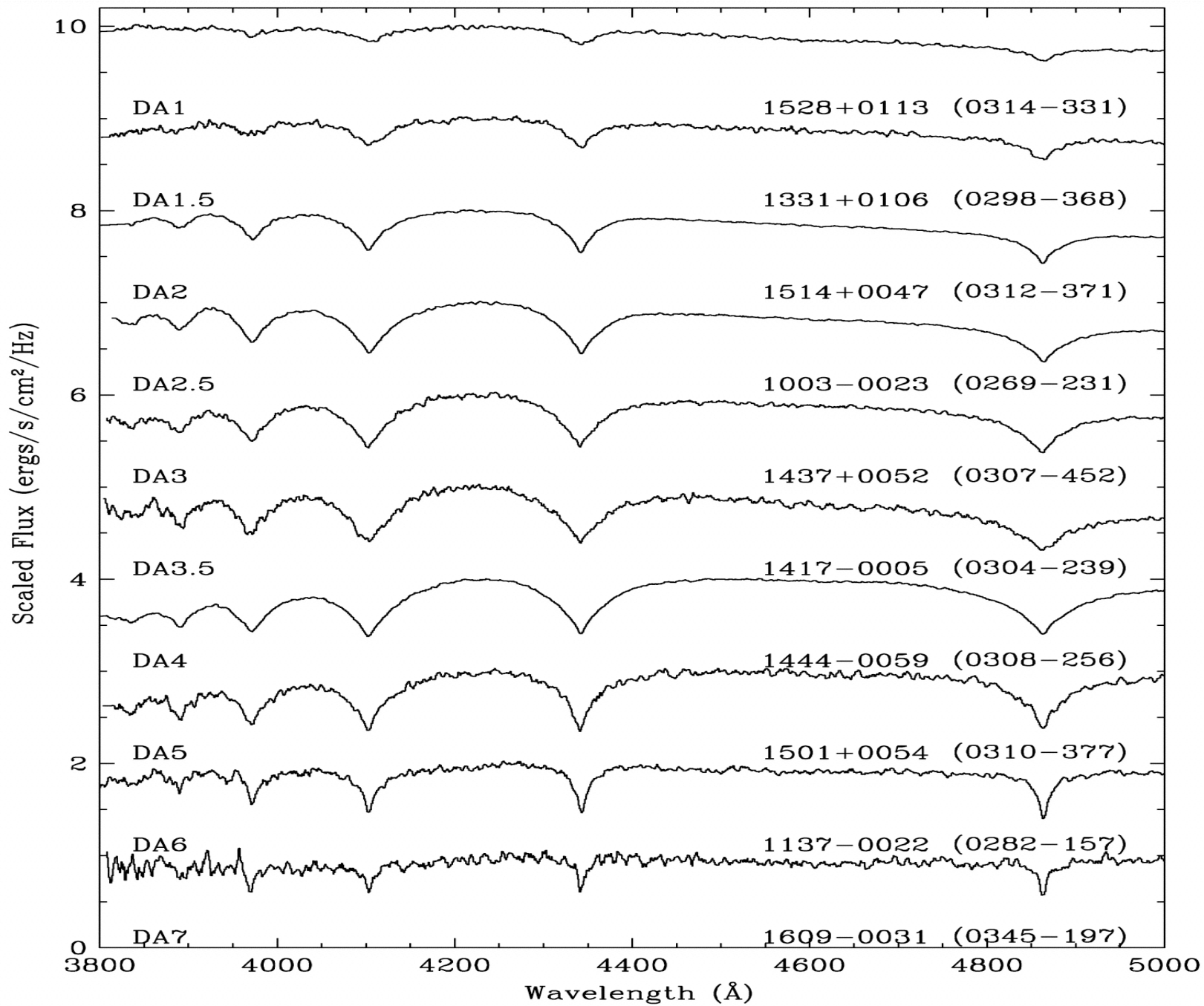
25,000 K

17,000 K

12,000 K

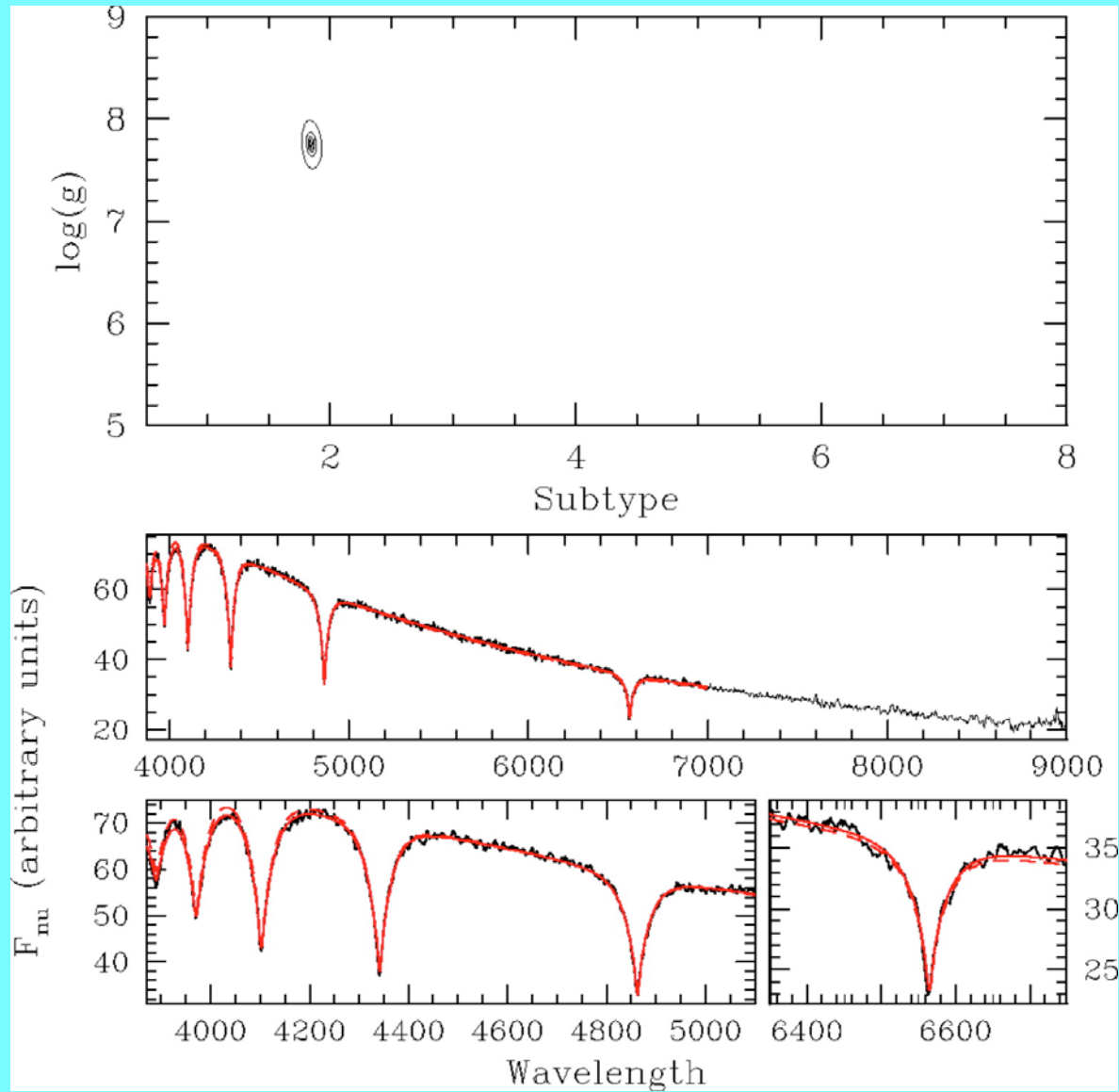
8,000 K

Harris et al.



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Temperature Index Subtype -- $50,400 / T_{\text{eff}}$ -- easier than plotting T_{eff}

Daniel Eisenstein -- Cosmologist and Cataloguer of 9,316 White Dwarfs



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1) $g = GM_*/R^2$

2) $R = R(M_*, T, m_H)$

Evolutionary (cooling) sequences

Wood (1992, 1995)

Fontaine (2001, 2005)

Get M_* R_*

Well established procedure for measuring
parameters of field white dwarfs --
accurately

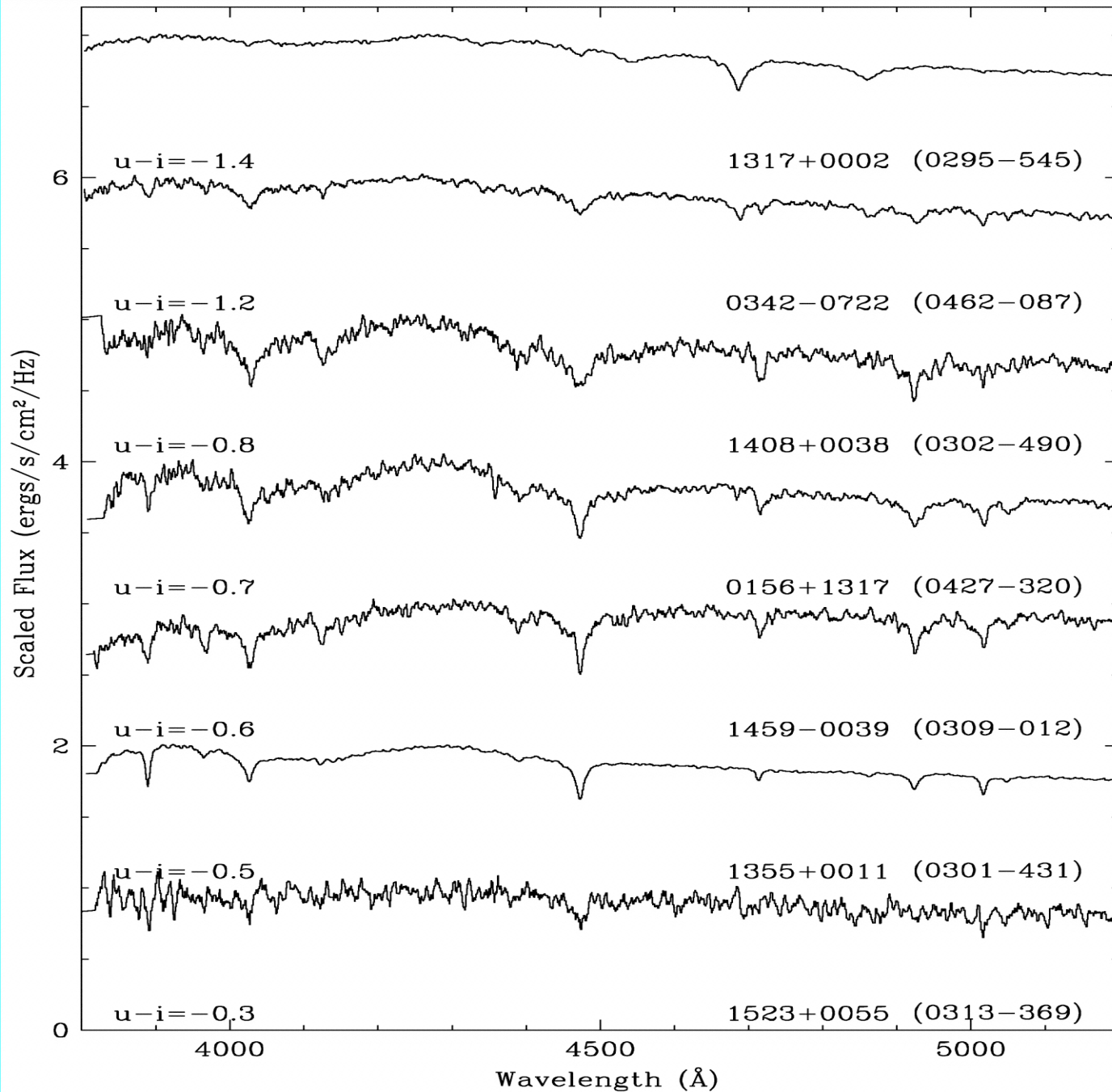
60,000 K DO

48,000 K

28,000 K DB

11,000 K

Harris et al.



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92 White Dwarfs from Luyten Half Second Survey

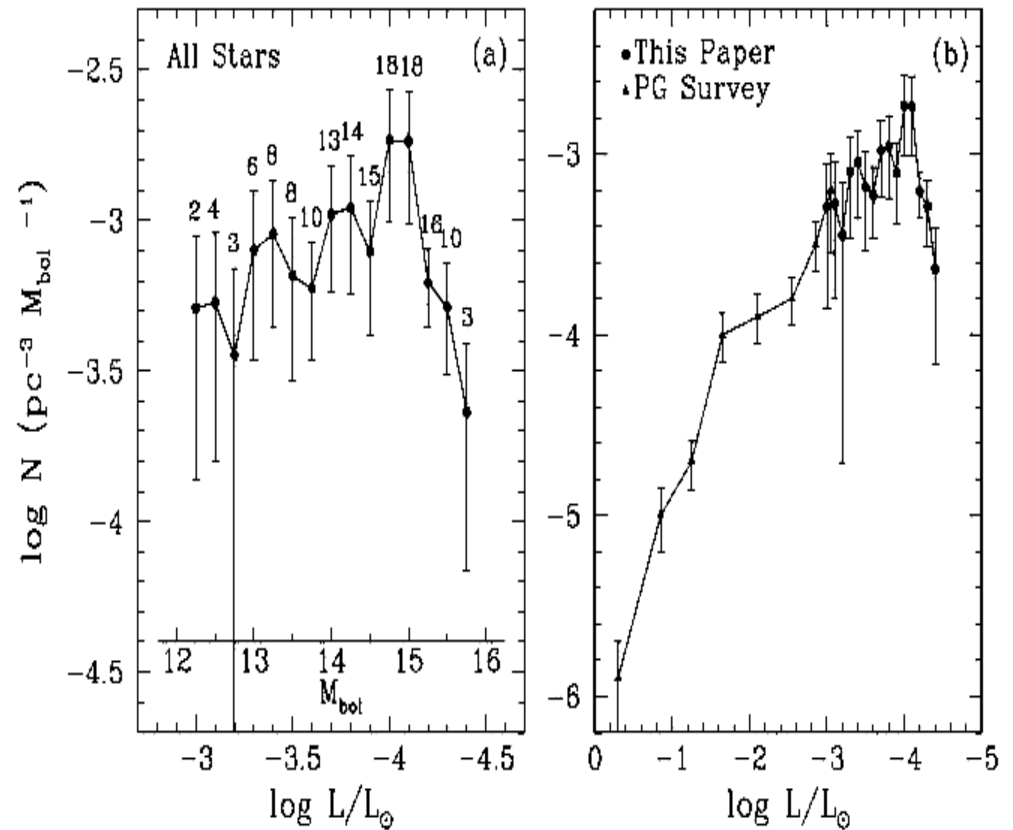
With $\mu > 0.6''$ / yr

1/4 mag bins

Hot stars from old PG WDLF

16, 10 and 3 stars
In last 3 bins

Dahn, Harris, Leggett, Liebert
In prep.



U.S. Naval Observatory trig π values for all but 2

Sloan Digital Sky Survey 2.5-meter

- o Catalog of 9,000+ White Dwarfs
- o Most are Hot DA,DB..
- o Eisenstein et al. 2006



Apache Peak, near Sunspot, NM

My Collaborators

Mukremin Kilic (U. Texas Austin) >> Ohio State
Ted von Hippel
Don Winget
Kurtis Williams (U. Arizona >> U. Texas Austin)
Jeff Munn (U.S. Naval Observatory, Flagstaff)
Hugh Harris
Stephen Levine
Travis Metcalfe (U. Colorado)

Telescopes for followup work:
6.5m MMT
"8m" Hobby Eberly Telescope
A little Keck I 10m time
McDonald Observatory 2.7m

And for other SDSS White Dwarf Projects

Daniel Eisenstein (U. Arizona)
Scot Kleinman (APO, New Mexico)
Atsuko Nitta Kleinman (APO)
Matt Wood (Fla Tech)
Terry Oswalt
Harry Shipman (U. Delaware)
J. Allyn Smith (LANL)
Didier Saumon

Hot DB white dwarfs
Hot DO white dwarfs
Ultralow and high masses
ZZ Ceti pulsating DA stars
Hot DQ white dwarfs
DZ white dwarfs vs. weak-lined MS Stars

Harris et al. et al.
2003 AJ 126, 1023

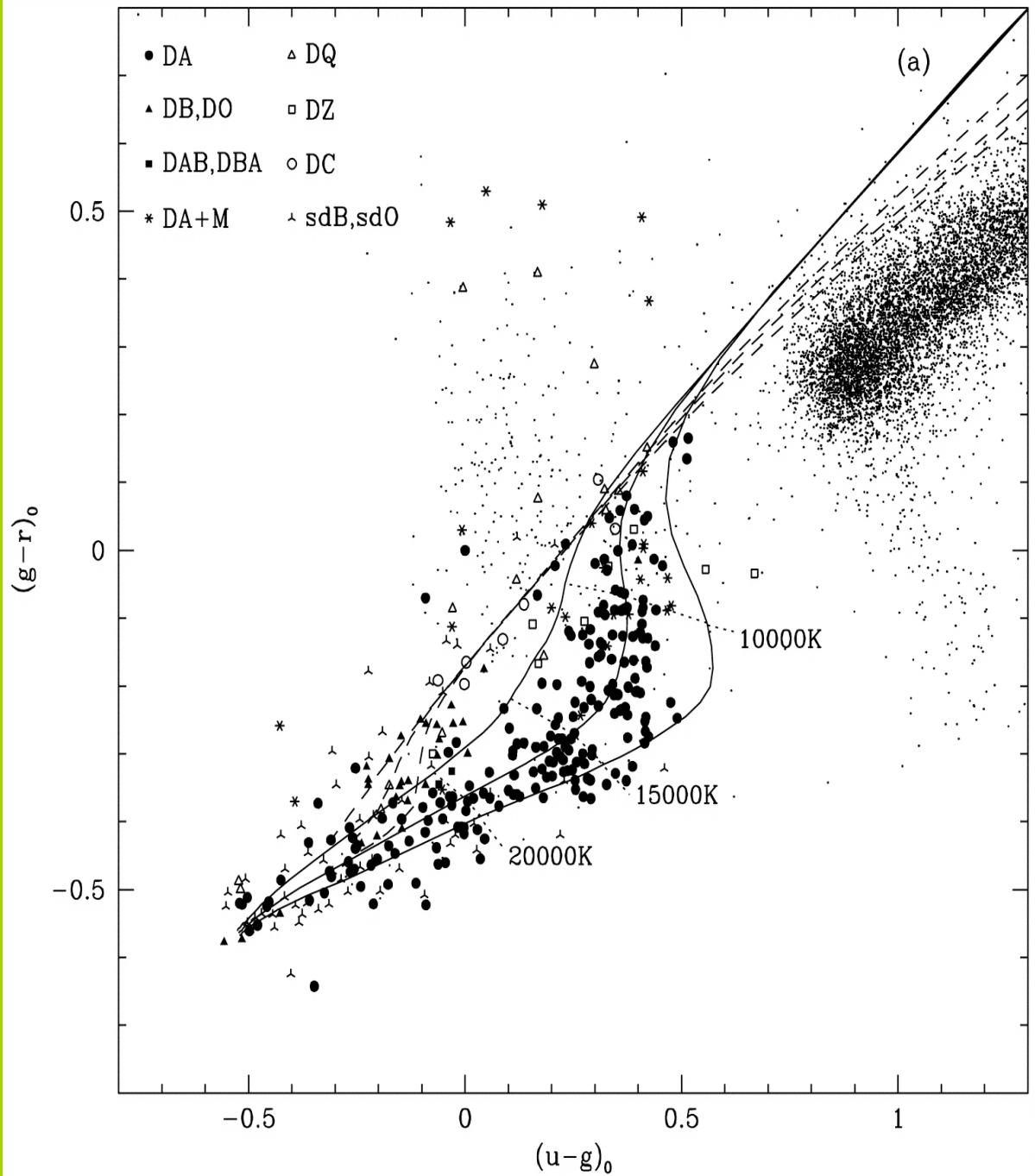
Initial Survey from
Early SDSS Spectra

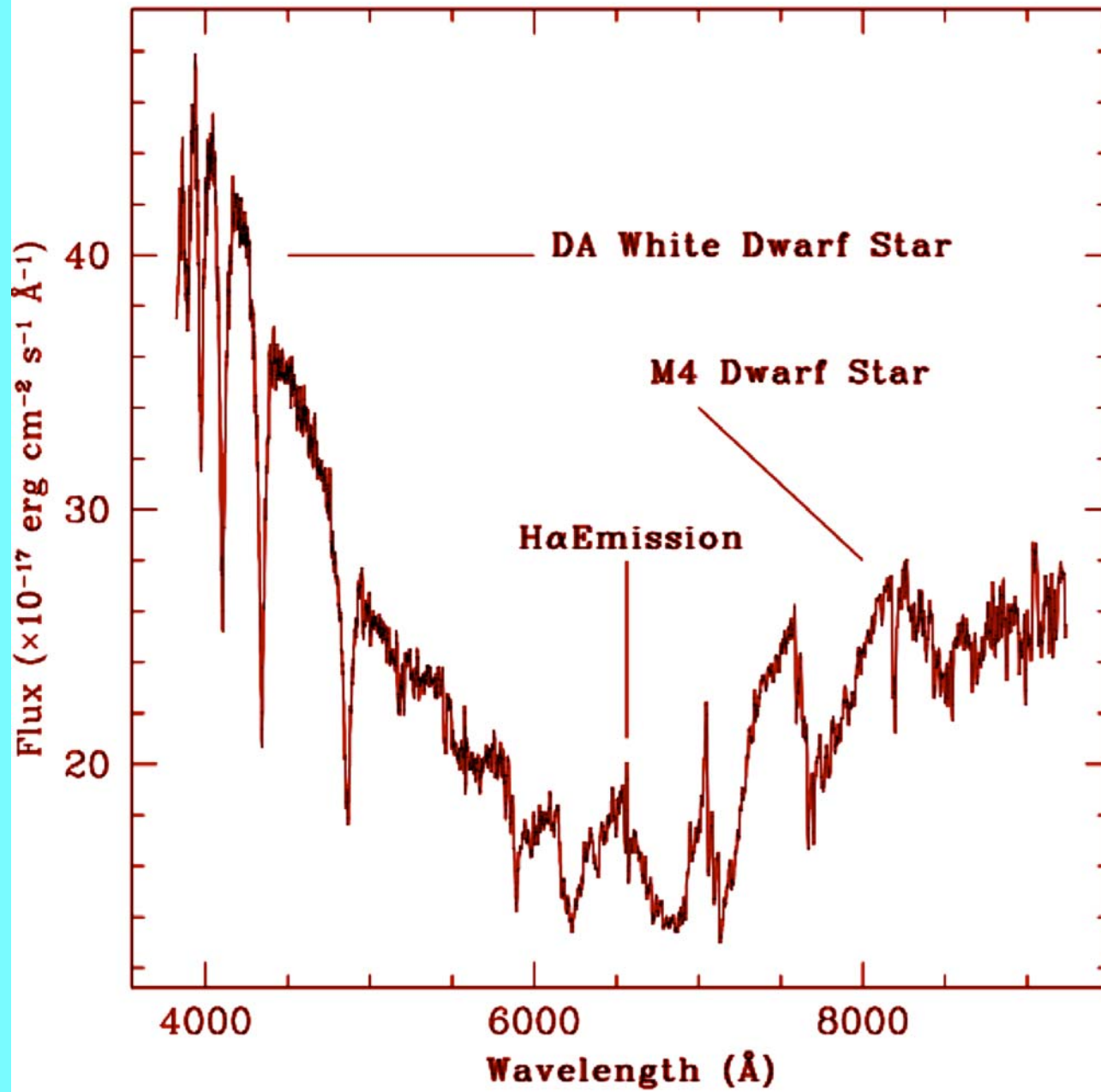
Model tracks from
P. Bergeron

Filled Curves: Hydrogen

Dashed: Helium

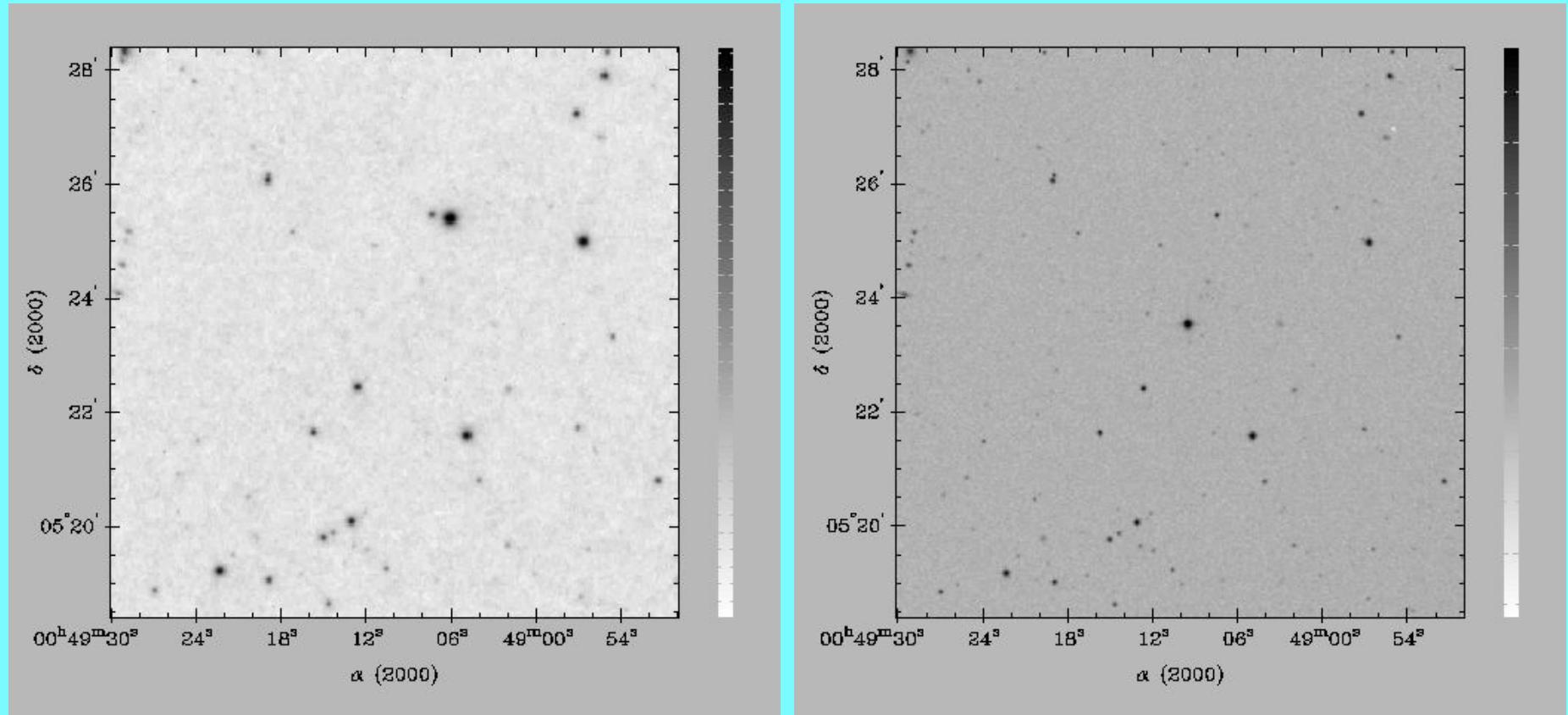
Blackbody Line





POSS 1 (early 1950s)

POSS 2 (80s and 90s)

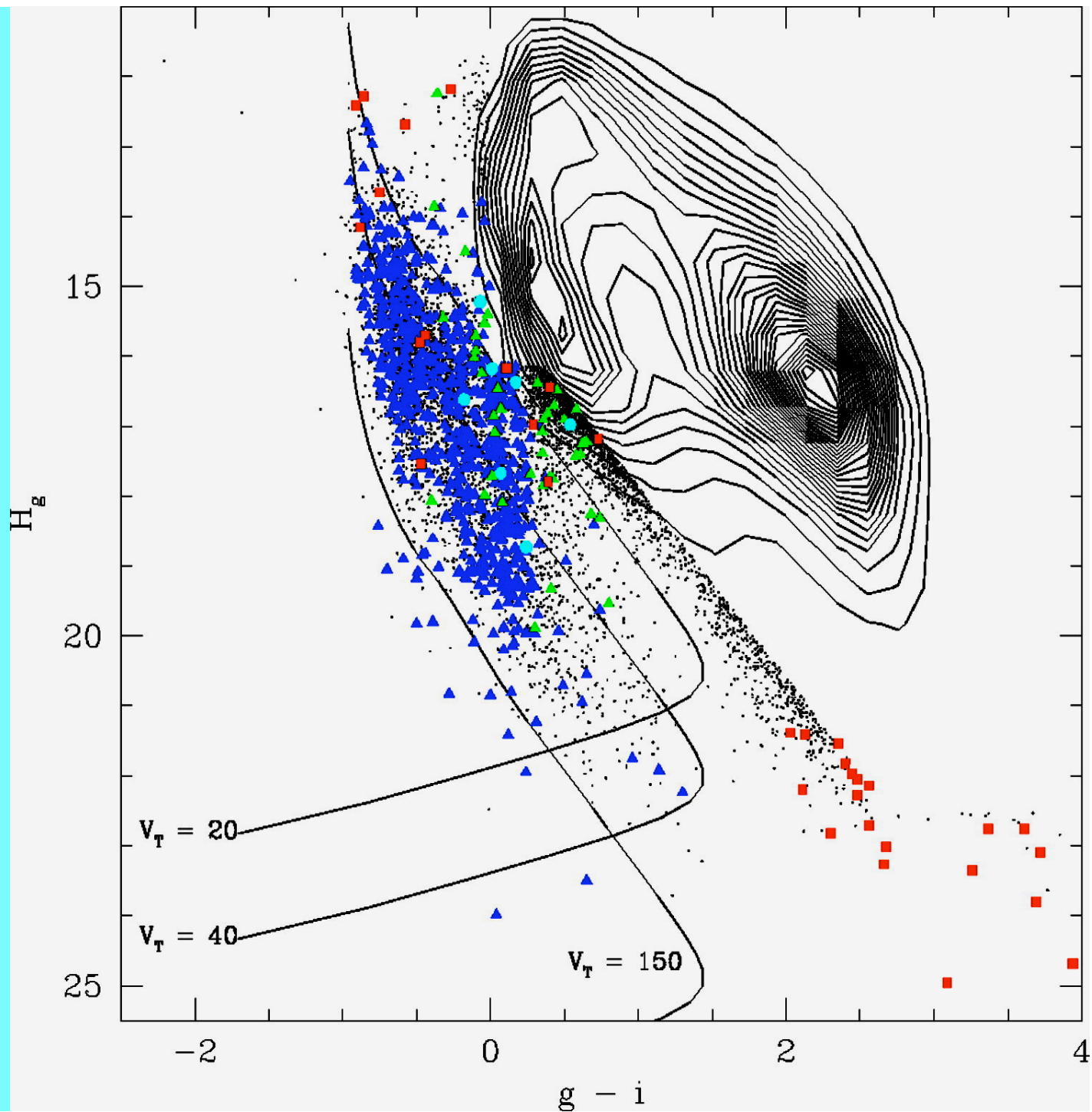


van Maanen 2 12th Magnitude DZ, Sun's 25th nearest neighbor
13.9 light years -- proper motion is 2.95 arc sec per year
(39th largest proper motion)
It's about the T_{eff} of the Sun but atmosphere shows
Helium and Heavy Metals (no Hydrogen)!

Reduced
Proper
Motion

Proxy for
Absolute Magnitude

$$H = g + 5 \log \mu + 5$$



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MMT Spectra of Cool White Dwarfs
Most are simple DA, DC or weak DZ

..but a few present problems ..

From Kilic et al.
2006 Astron. J., 131, 582

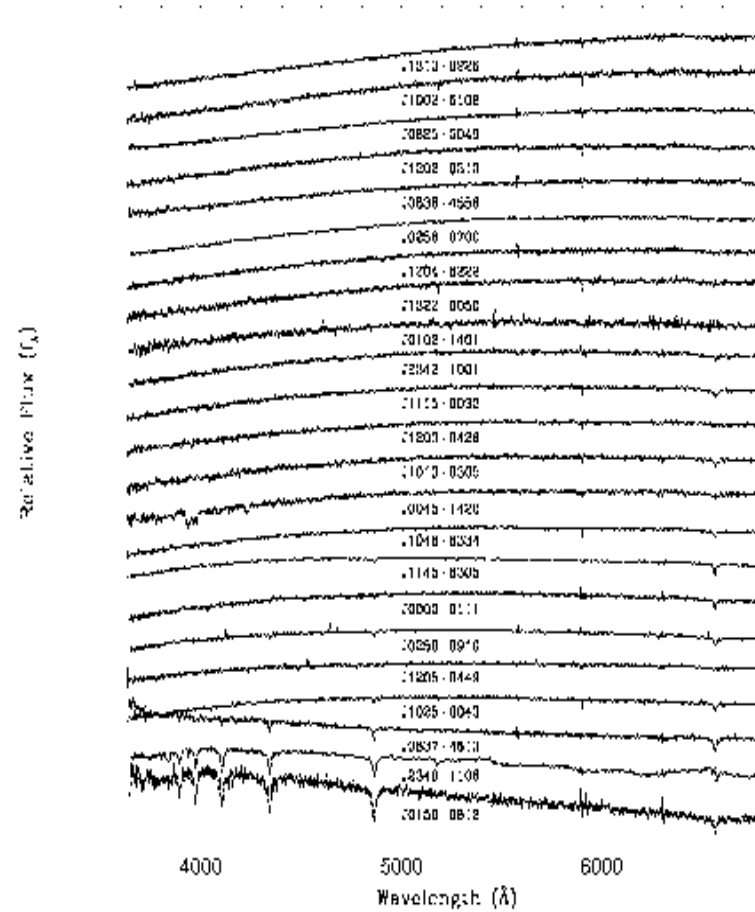


Figure 3

5794 SDSS stars

RPM selection

H. Harris et al.,
2006 Astron. J., 131, 571

Spectral confirmation

For several hundred
With 6.5-m MMT,

“8-m” HET and
Smaller telescopes

M. Kilic et al. 2006 Astron J.

..but

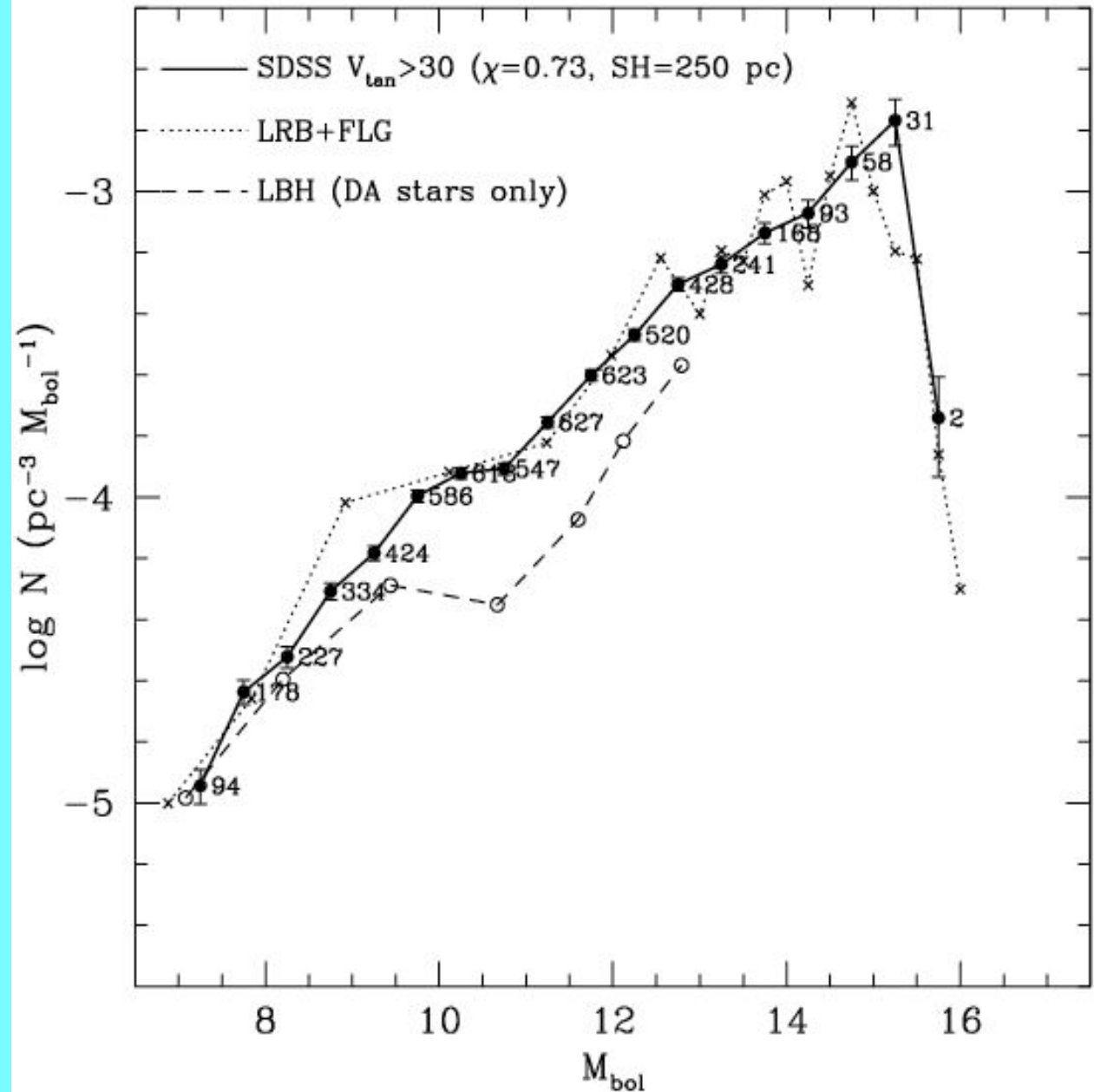
Only 2 in last 1/2 mag

RPM reliability requires

4 good measurements

..on POSS1 blue,red

..and POSS2 b,r,ir plates



Less than 100 LHS Stars

but...

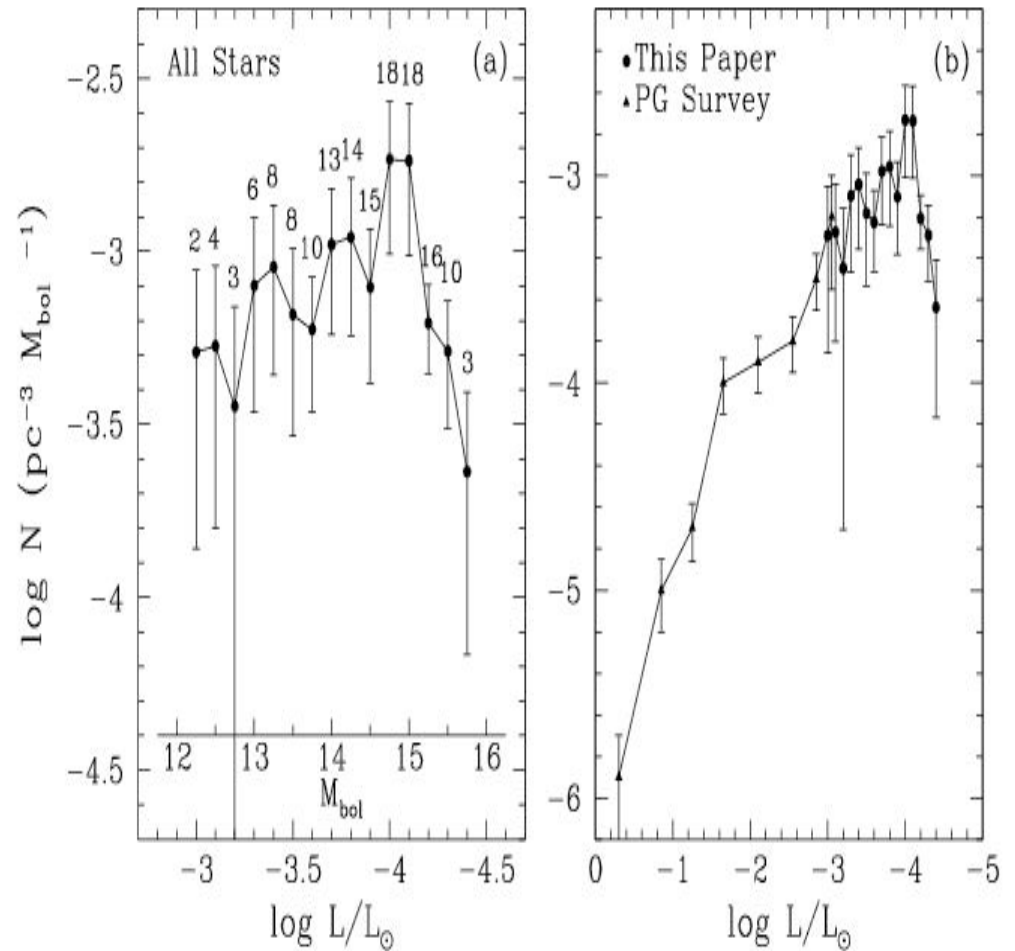
16 + 10 + 3 are in the
Critical 15-16 Magnitude
bin!

For the SDSS Sample..

To measure a valid RPM:

Need valid point source PSF
From SDSS + Four POSS Plates!

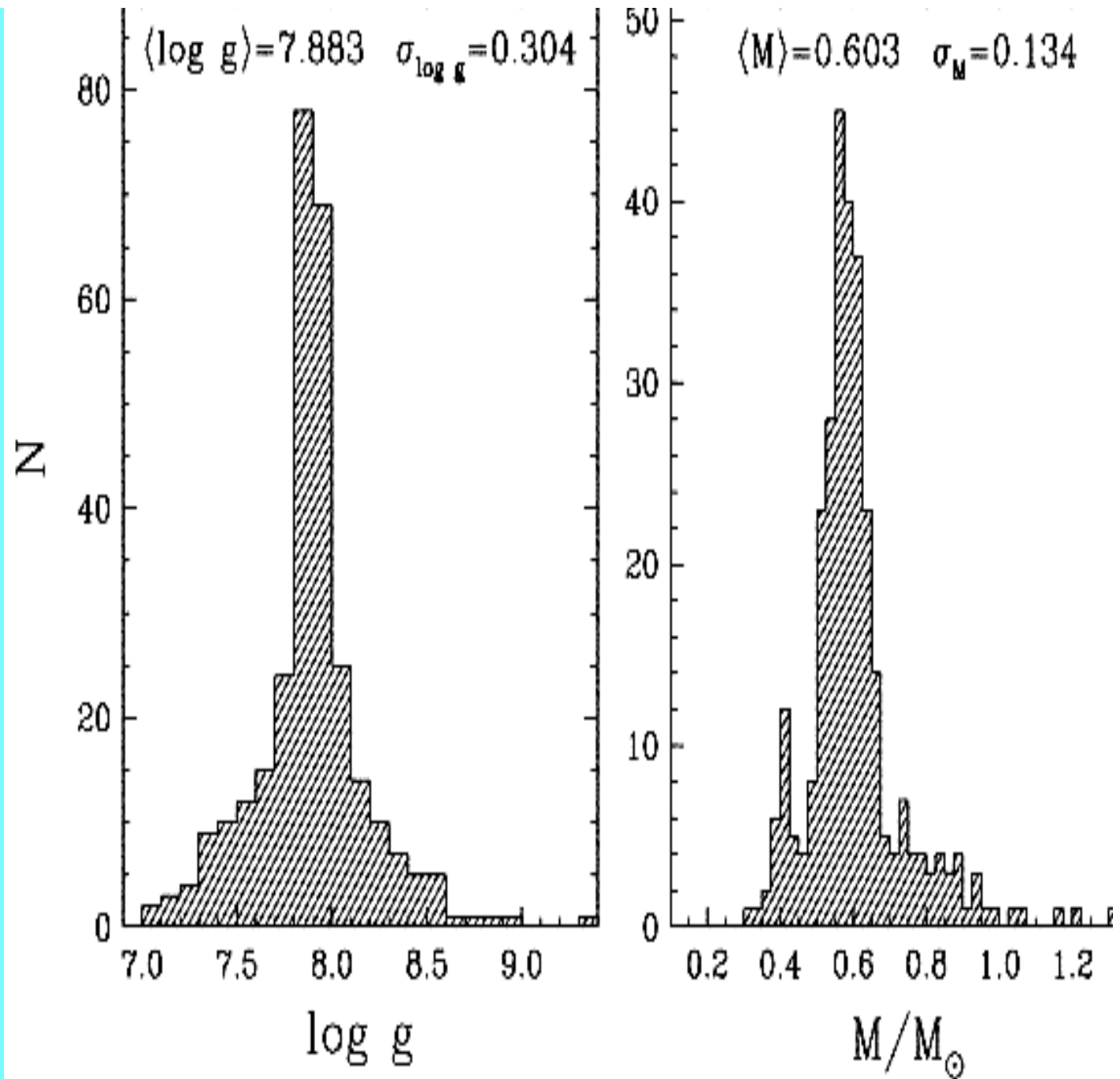
Need a 2nd Epoch that
GOES DEEP!
(SDSS Depth)



Liebert, Bergeron, Holberg

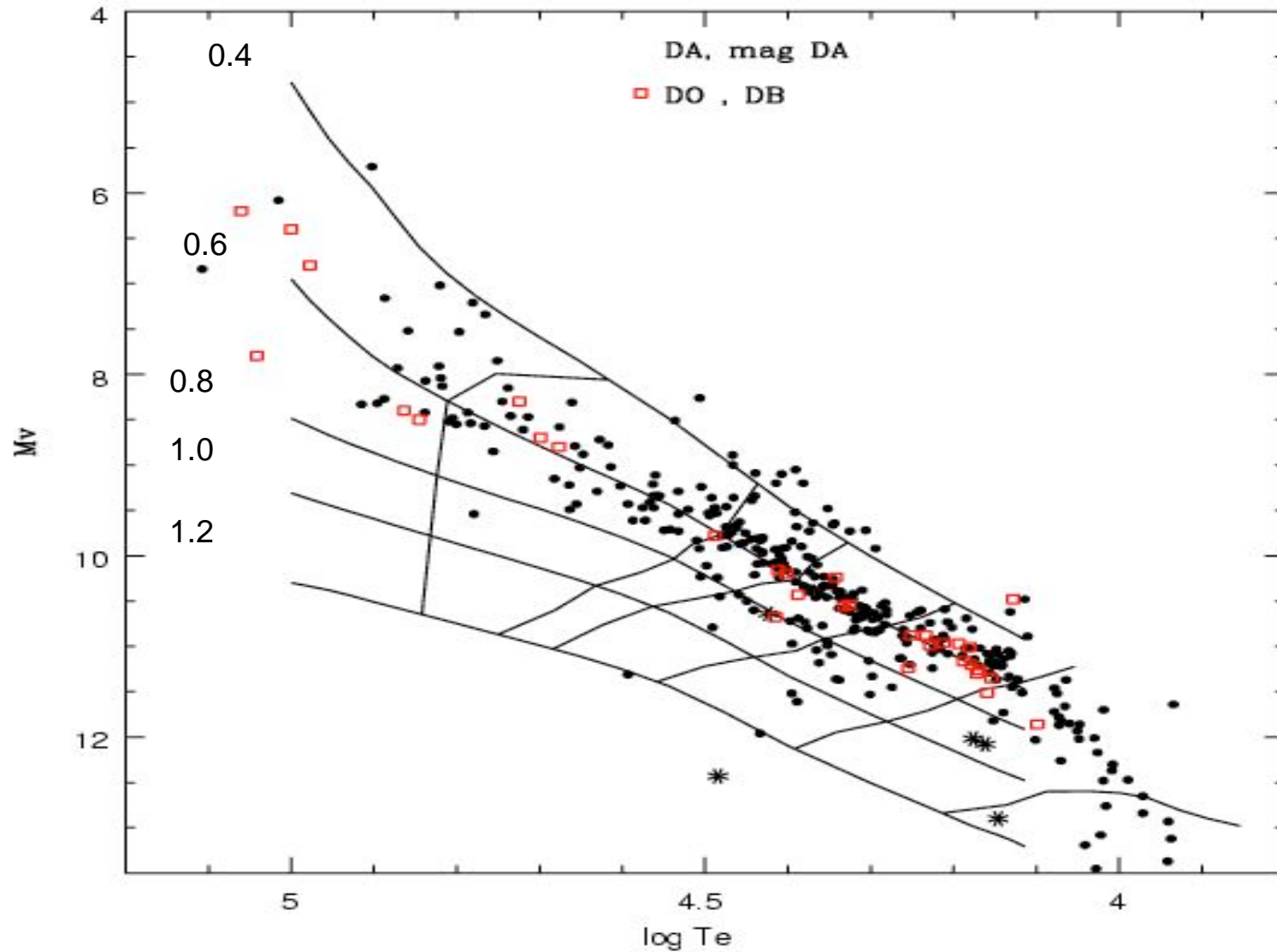
348 DA White Dwarfs

From the
Palomar Green Survey



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Mass and Luminosity Function(s) of Hot White Dwarfs from the PG Survey
 Liebert, P. Bergeron, J. Holberg 2005 ApJS, 156, 47

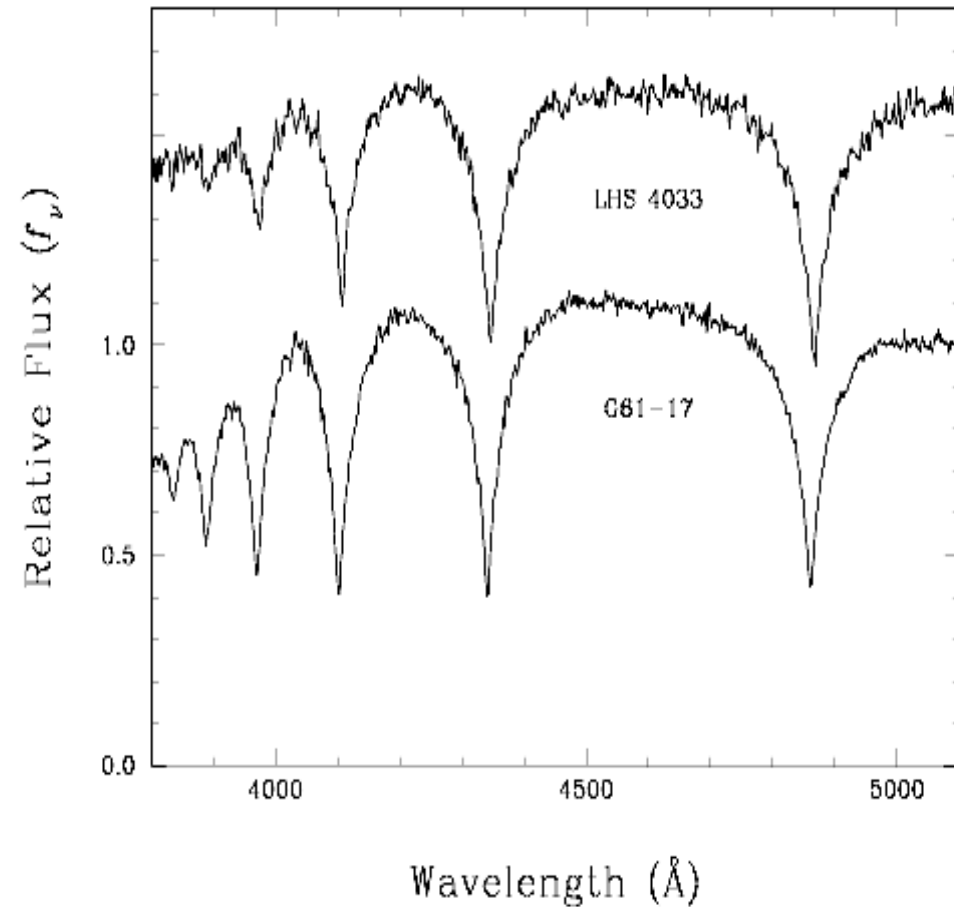
LHS 4033
Most Massive
Well Measured
White Dwarf

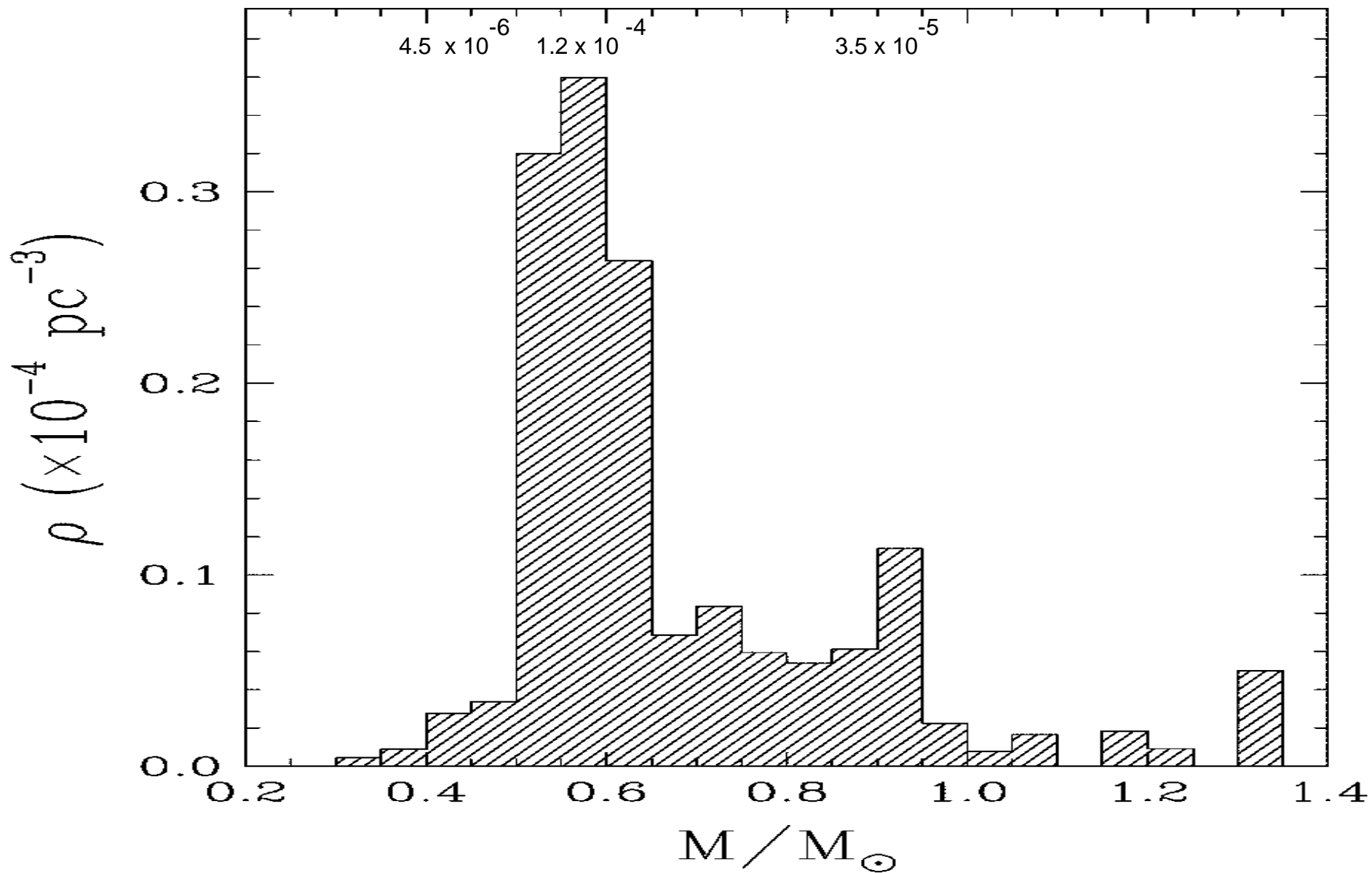
$1.31-1.335M_{\odot}$

10,900 K

$0.0037R_{\odot}$

Dahn, Bergeron, Liebert,
Harris, Canzian, Leggett,
And Boudreault
2004 ApJ, 605, 400





Mass Distribution Corrected to Fixed Volume of Space

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