Calibrating Large Photometric Surveys Using Hot White Dwarfs

Jay B. Holberg

University of Arizona

DA White Dwarfs and Synthetic Photometry

I. DA White Dwarfs Placed on the HST Photometric Scale

Holberg & Bergeron (2006) AJ, 132, 1221

II. DA White Dwarf Distances

Holberg, Bergeron & Gianninas (2008) AJ, 135, 1239

Topics

I. DA White Dwarfs as Absolute Flux Standards

(Synthetic Photometry)

II. Estimating the Projected Density of White Dwarfs on the Sky

Synthetic Photometry

$$f_\lambda = 4\pi H_\lambda(T_{eff}, \log g)(R^2 / D^2)$$

f_λ = Observed flux at the top of the Earth's Atmosphere

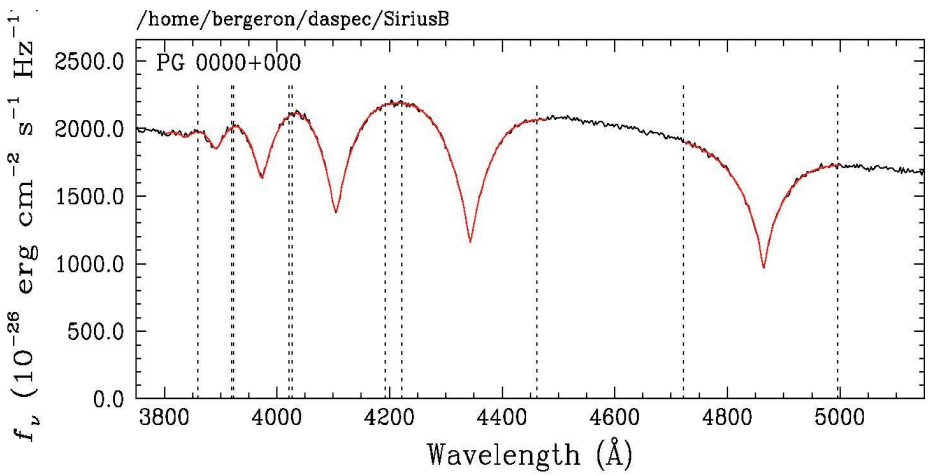
$H_{\lambda(}T_{eff}$, log g) = Eddington Flux at the Stellar Surface

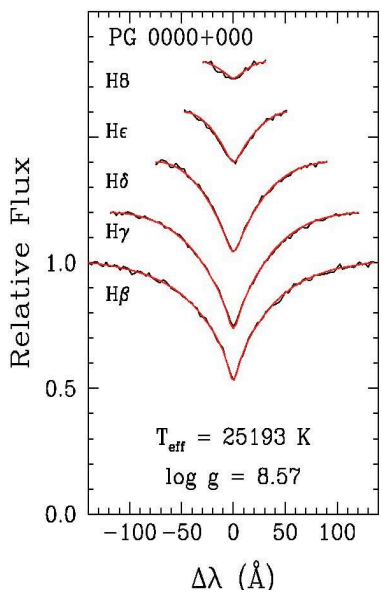
R = Stellar Radius (Mass-Radius Relation)

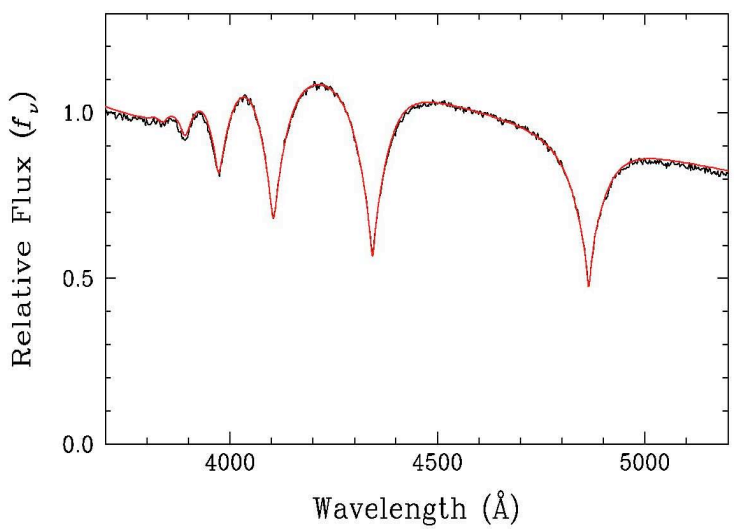
D = Stellar Distance

Spectral Fitting for T_{eff} and log g

Sirius B







Absolute Magnitudes

$$F_s = \frac{\int f(\lambda) S(\lambda) d\lambda}{\int s(\lambda) d\lambda}$$

Stellar flux integrated over band-pass

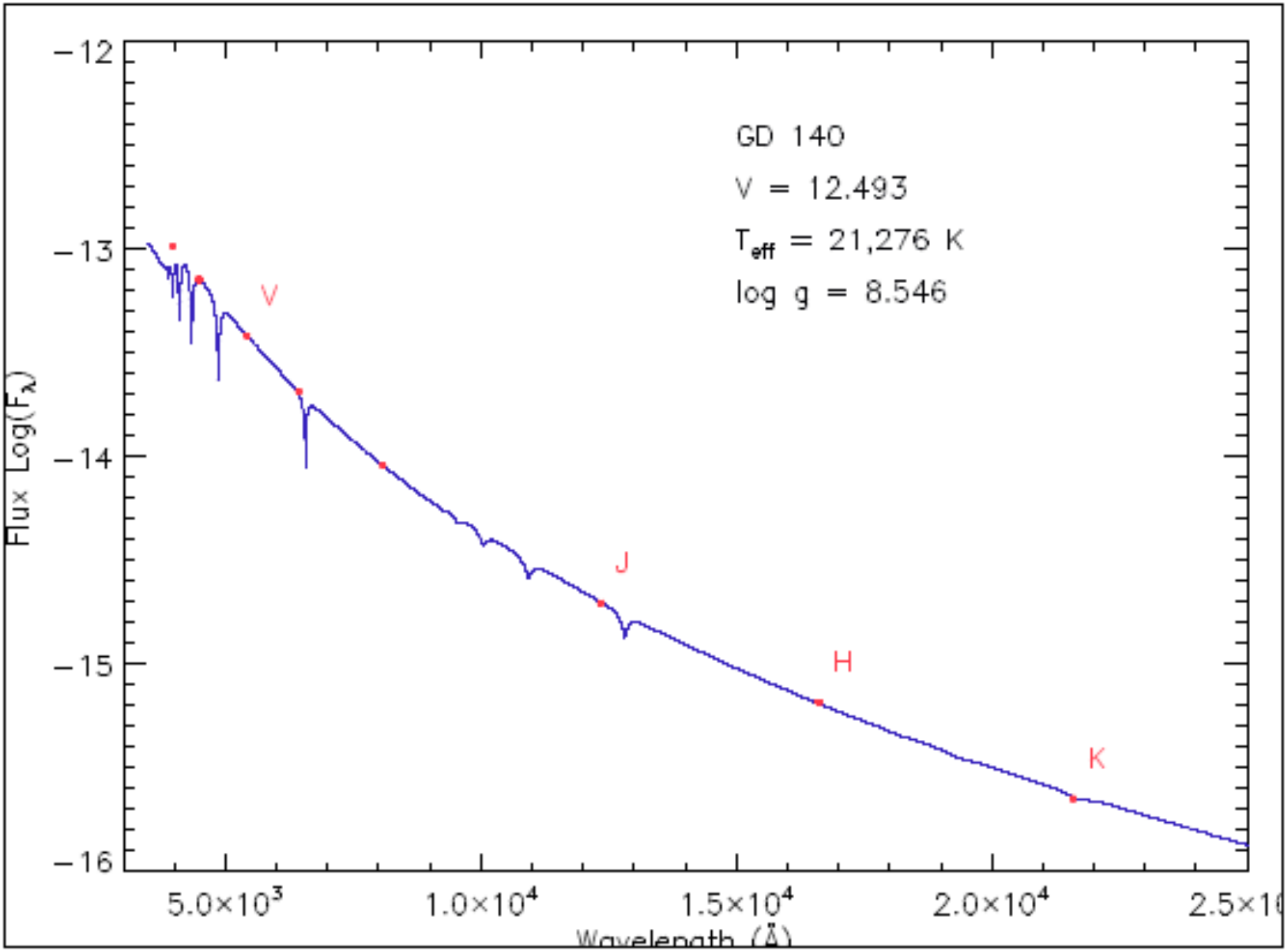
$$M_s = -2.5 \log(F_s) + C_s$$

Synthetic Magnitude for band-pass S

The constant C_s can be defined with respect to Vega

For DA white dwarfs C_s can be defined so that M_s is the absolute magnitude for band pass S as function of T_{eff} and log g. Note this requires knowledge of the relative response of the band-pass.

Example


GD 140
V = 12.493
T_{eff} = 21,276 K
log g = 8.546
V
J
H
K
−12
−13
−14
−15
−16
Flux Log(F_λ)
5.0×10³
1.0×10⁴
1.5×10⁴
2.0×10⁴
Wavelength (Å)

Example

GD 140 (WD 1134+300)

T_{eff} = 21,276 K & log g = 8.545

Abs Mag.	MU	MB	MV	MR	MI	MJ	MK	MH
Synth	10.464	11.477	11.545	11.661	11.778	12.080	12.151	12.233
Obs	U	B	V	R	I	J	K	H
	11.377	12.400	12.493	12.603	12.723	12.993	13.105	13.183
Obs-Syn	0.913	0.923	0.948	0.942	0.945	0.913	0.945	0.950

Ave (O-S) = 0.934

*** http://www.astro.umontreal/~bergeron/CoolingModels**

Distances

$$\mu = M_{obs} - M_{abs}$$ **Distance Modulus**

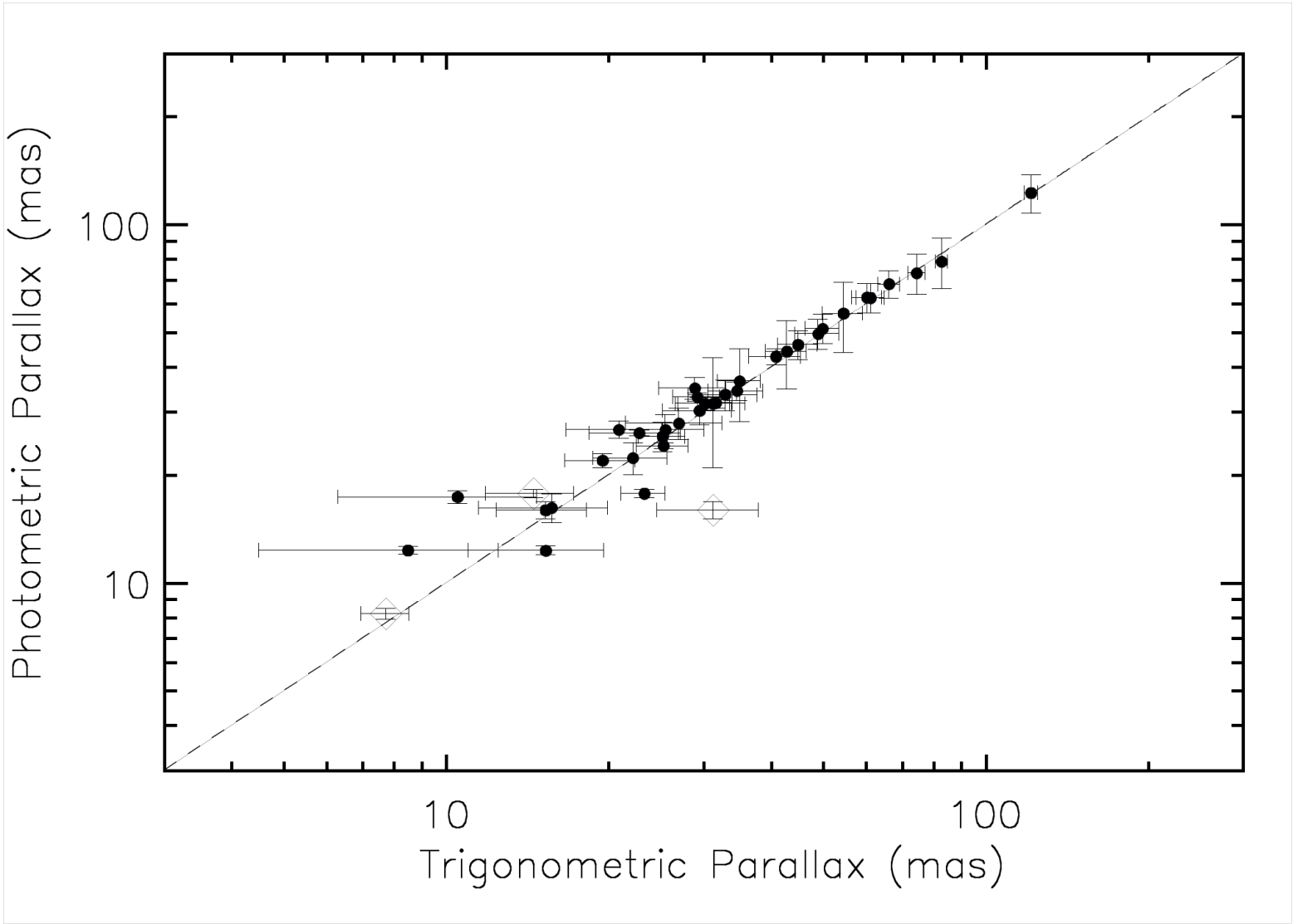
$$D = 5\log(\mu/10)$$ **Distance (pc)**

GD 140 (UBVRI+JHK) D = 15.38 ± 0.25 pc

GD 140 (ugriz) D = 15.44 ± 0.25 pc

GD 140 1/π (*Hipparcos*) D = 15.32 ± 0.63 pc

Correlation of ‘Photometric Parallaxes with Trigonometric Parallaxes



Estimating the Areal Density of Hot White Dwarfs

$$N(b^{II}) = n_0 f \frac{h^3 d\Omega}{Sin(b^{II})^3}$$

No. of Hot WDs/sq. deg.

b^{II} : Galactic Latitude

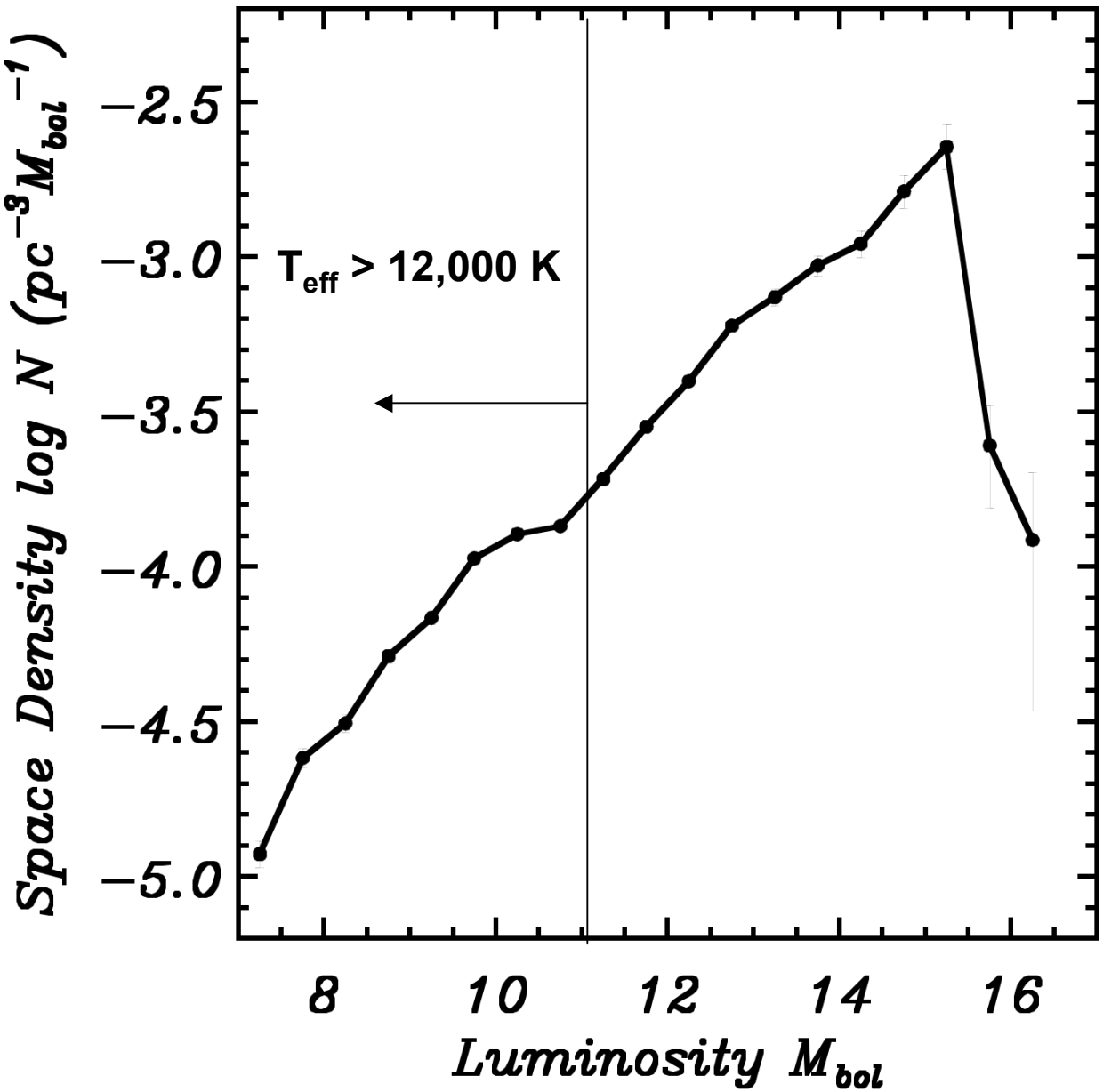
h : Galactic Scale Height of WDs

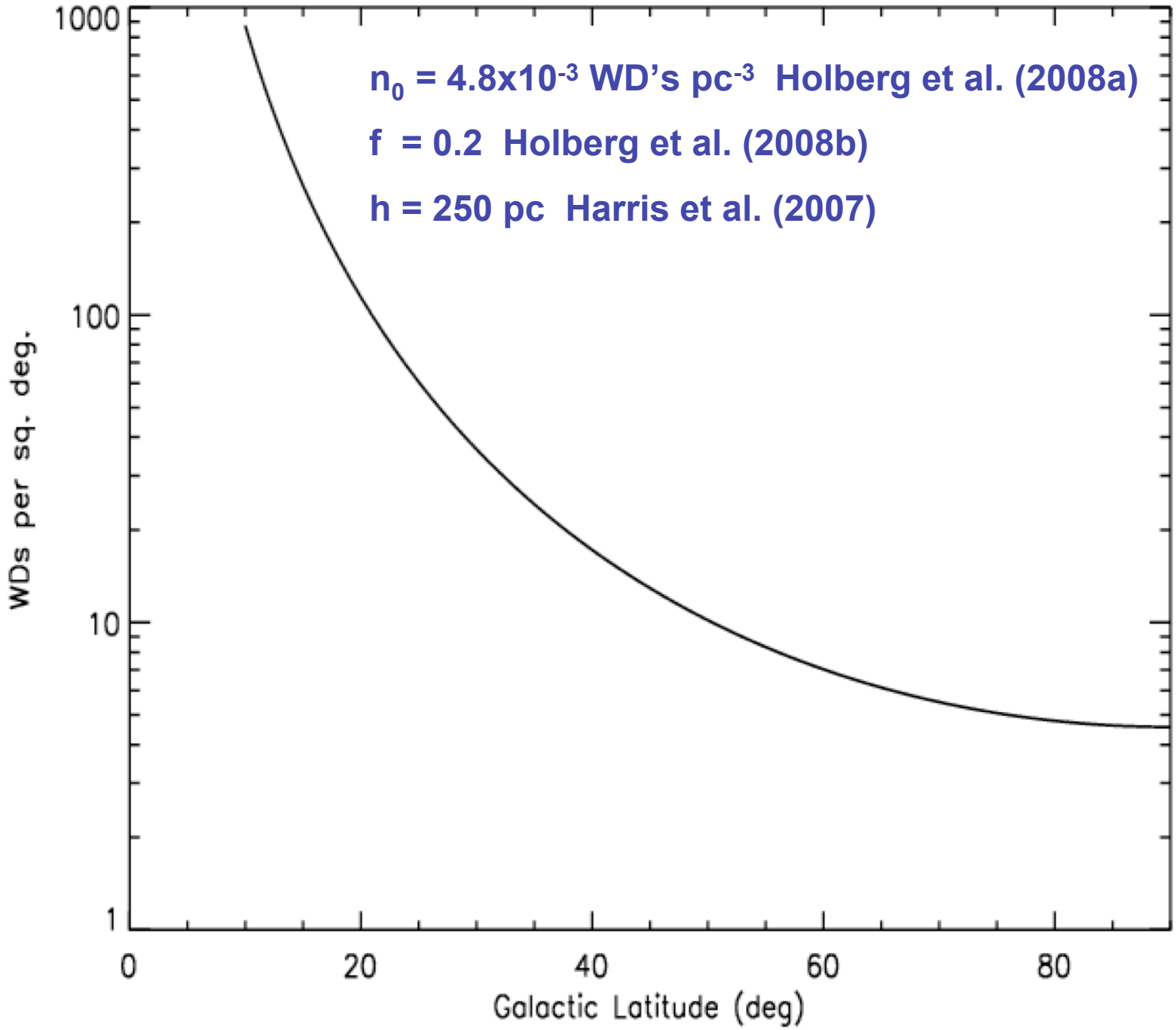
n_o : Local Space Density of WDs[1]

f : Fraction of Hot WDs

[1] **Holberg, et al. (2008b) AJ, 135, 1225**

Harris et al. (2007) Luminosity Function




n_0 = 4.8x10^{-3} WD's pc^{-3} Holberg et al. (2008a)
f = 0.2 Holberg et al. (2008b)
h = 250 pc Harris et al. (2007)
1000
100
10
1
WDs per sq. deg.
0
20
40
60
80
Galactic Latitude (deg)

Summary

- **Calibrations based on DA white dwarfs have a <u>Strong Physical Basis</u>**
- **They are applicable from the UV (and X-ray) into the Near IR**
- **They are widely distributed in magnitude and over the sky**
- **Photometric calibrations based on white dwarfs should be easy to compare between different large surveys and different filters.**

Other Considerations

- In general white dwarfs are blue objects
- They may not be sufficiently densely distributed over the sky so that there is a suitable standard in every field.