Fotometría Astronómica

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Astronomía observacional

$$F_\lambda = \alpha \int_{\lambda_1}^{\lambda_2} T_i(\lambda, d) T_a(\lambda, d) T_t(\lambda) T_f(\lambda) r(\lambda) f_\lambda d\lambda$$

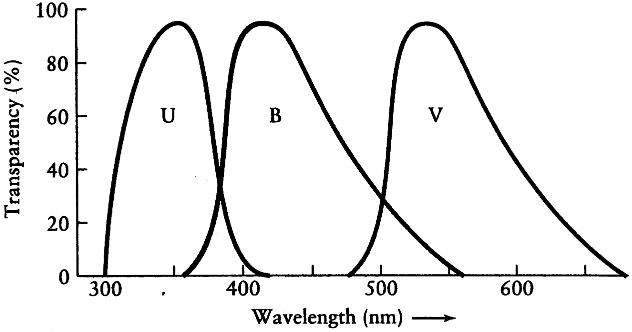
Sistemas fotométricos

- Conjunto de rangos espectrales
- Conjunto de magnitudes, colores e índices propios del sistema
- Lista de estrellas estándar con sus valores

Sistemas fotométricos

- Magnitudes visuales m_v
- Magnitudes fotográficas m_{pg}
- Índice de color $CI = m_{pg} - m_v$

Sistema de Johnson



Sistema de Johnson

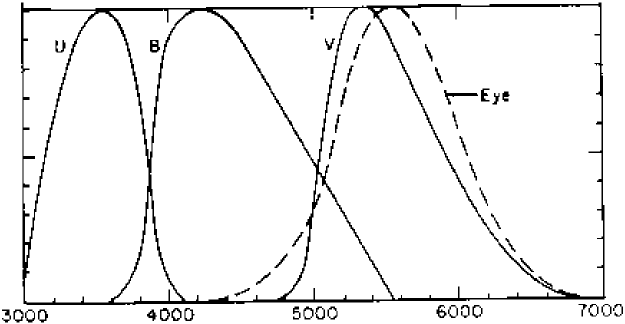
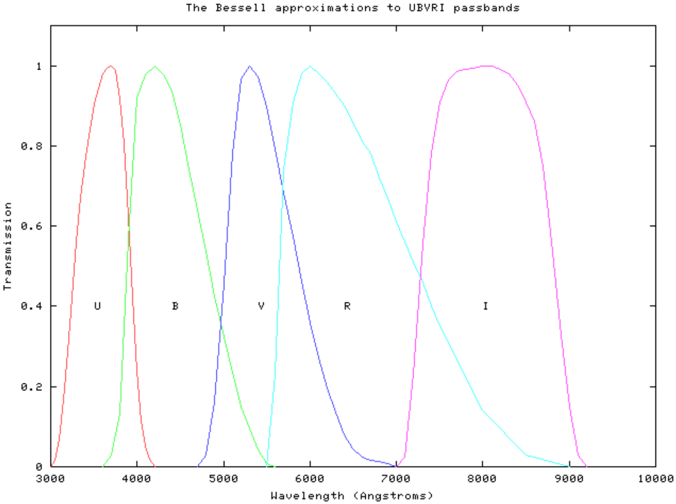
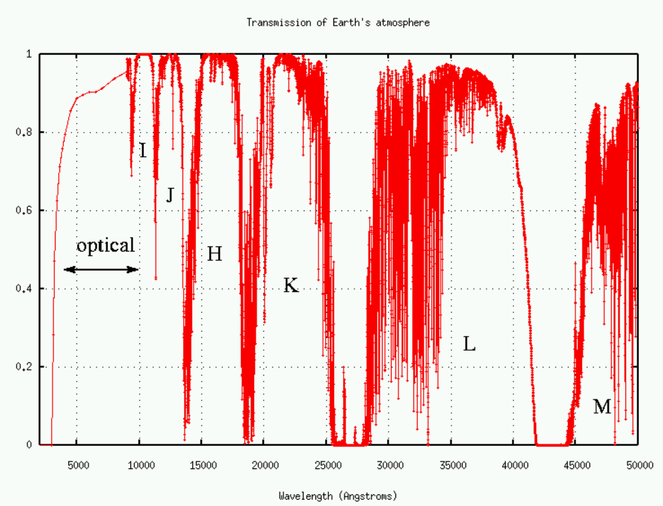


Fig. 1–4. Sensitivity Curves of the Eye and of the UBV Photometric System

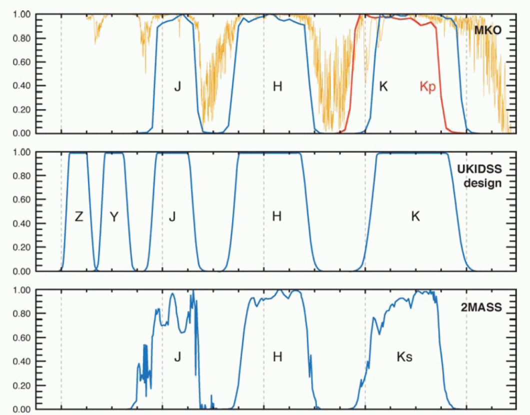
Sistema de Johnson-Cousins



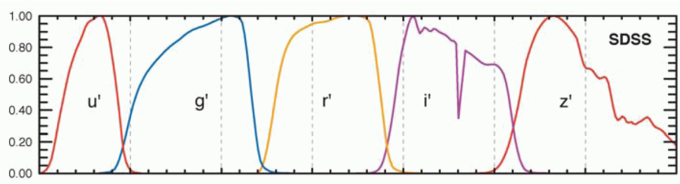
Transmisión de la atmósfera



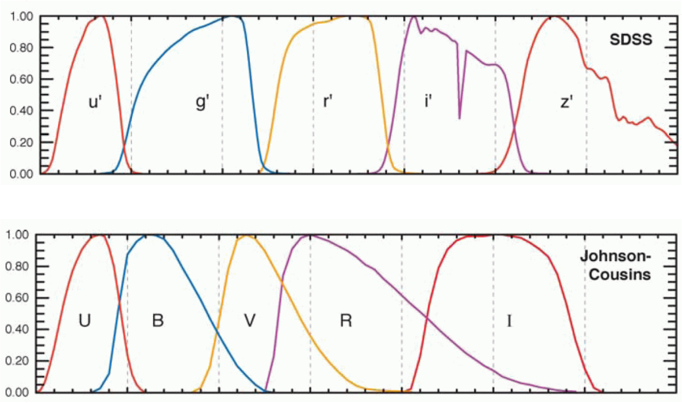
Sistema infrarrojo



Sistema de Sloan



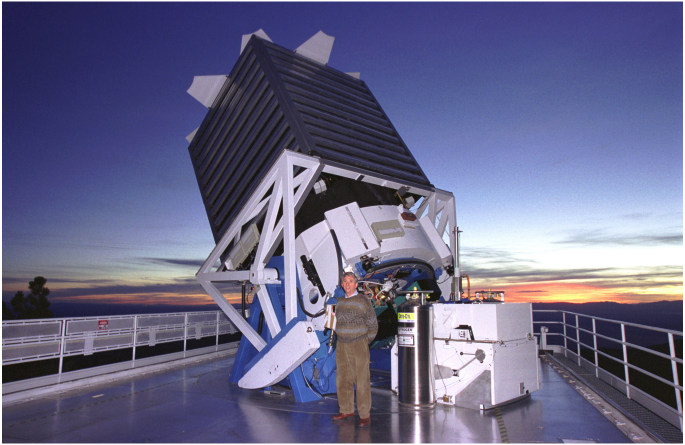
Sistema de Sloan



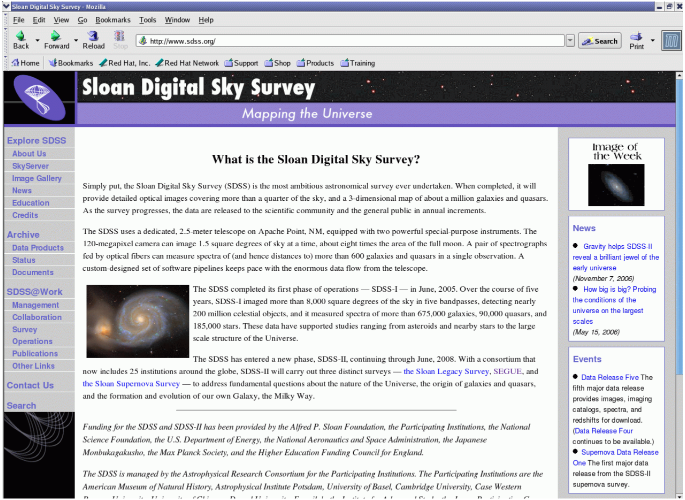
Sistema de Sloan

- Imágenes ópticas de más de un cuarto del cielo
- Mapa tridimensional de un millón de galaxias y quasares
- Telescopio dedicado para fotometría y espectroscopía
- `http://www.sdss.org/`

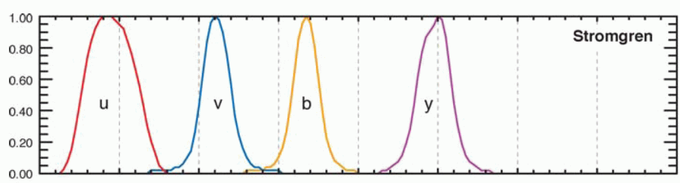
Sistema de Sloan



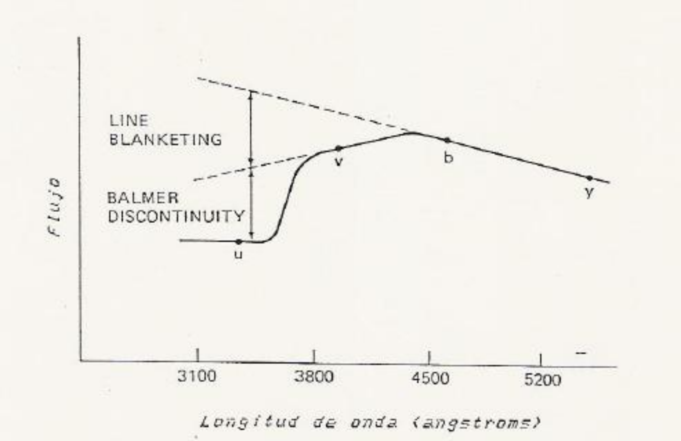
Sistema de Sloan



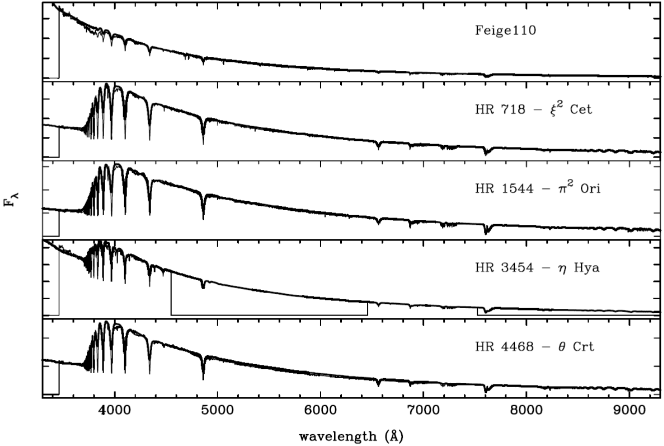
Sistema de Strömgren



Sistema de Strömgren



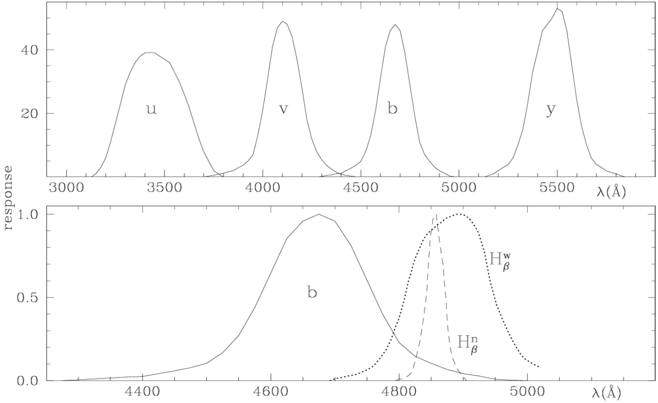
Sistema de Strömgren



Sistema de Strömgren

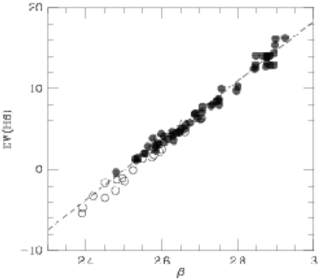
- $V \equiv V$ de Johnson
- $(b - y)$
- $m_1 = (v - b) - (b - y) = v - 2b + y$
- $c_1 = (u - v) - (v - b) = u - 2v + b$

Sistemas Hβ de Crawford

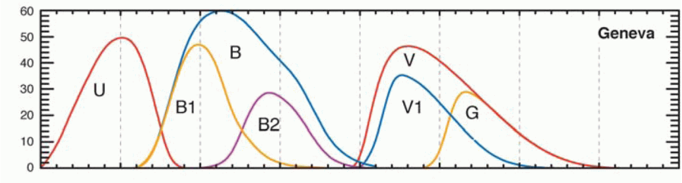


Sistemas Hβ de Crawford

$$\beta = mag(\beta_n) - mag(\beta_w)$$



Sistemas fotométricos



Extinción atmosférica

Un elemento de material absorbente o dispersor de espesor dx absorbe una una fracción τdx de un rayo de intensidad I. La cantidad dispersada es $I\tau dx$.

$dI = -I\tau dx$

Integrando a lo largo del recorrido x

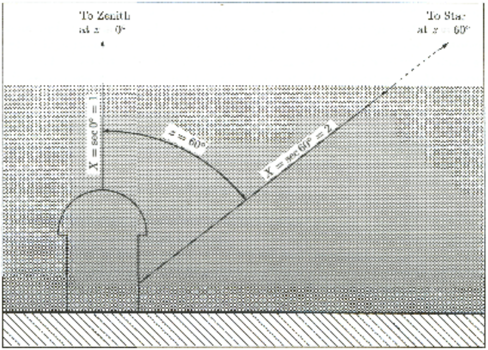
$\log I = \log I_0 - \tau x$

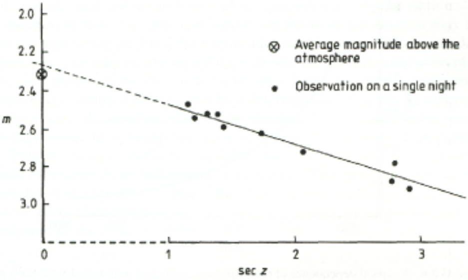
donde I e I_0 son las intensidades inicial y final. En magnitudes esto se convierte en:

$m_0 = m - 2.5\tau x$

$m_0 = m - kX$

Extinción atmosférica





2.0
2.2
2.4
2.6
2.8
3.0
m
Average magnitude above the atmosphere
Observation on a single night
0
1
2
3
sec z

- Magnitudes instrumentales fuera de atmósfera:
  $m_0(\lambda) = m(\lambda) - k_\lambda X$

- En el caso de bandas anchas:
  $m_0(\lambda) = m(\lambda) - (k_\lambda + k'_\lambda(B - V))X$

Transformación estándar

Ecuaciones de transformación estándar del sistema UBV de Johnson:

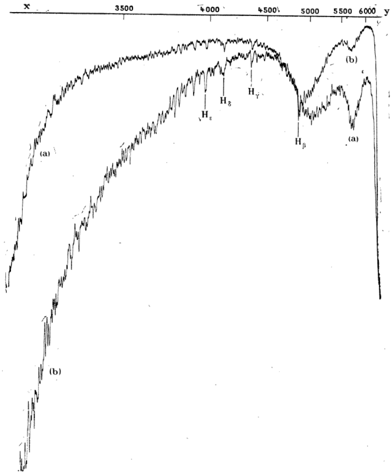
- $V = v_0 + \epsilon(B - V) + Z_v$
- $(B - V) = \mu(b - v)_0 + Z_{b-v}$
- $(U - B) = \psi(u - b)_0 + Z_{u-b}$

Transformación estándar

Ecuaciones de transformación estándar del sistema $uvby\beta$ de Strömgren-Crawf:

- $V = y + A + B(b - y)_{st}$
- $(b - y)_{st} = C + D(b - y)_{ins}$
- $m_{1(st)} = E + Fm_{1(ins)} + J(b - y)_{st}$
- $c_{1(st)} = G + Hc_{1(ins)} + I(b - y)_{st}$
- $\beta_{st} = a + b\beta_{ins}$

Extinción interestelar



Extinción interestelar

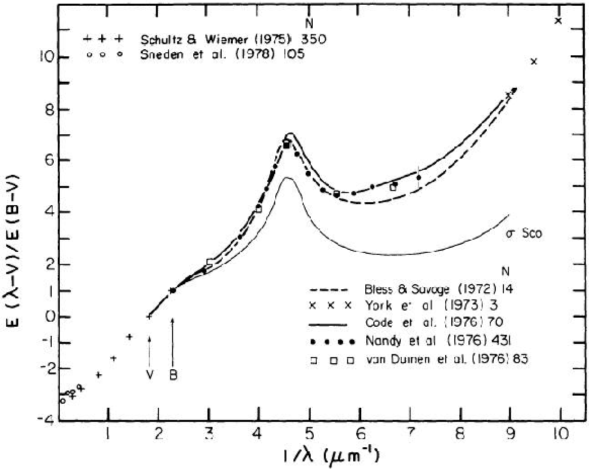
Índices intrínsecos. Absorción o extinción y exceso de color.

- Absorción: $A_M = M - M_0$
- Exceso: $E(C) = C - C_0$

Ejemplos:

- $V_0 = V - A_V$
- $(B - V)_0 = (B - V) - E(B - V)$
- $(b - y)_0 = (b - y) - E(b - y)$
- $c_0 = c_1 - E(c_1)$

Extinción interestelar



Extinción interestelar

INTERSTELLAR EXTINCTION LAW

λ	$E(\lambda - V)/E(B-V)$	A_λ/A_V	van de Hulst No. 15
U	1.64[a]	1.531	1.555
B	1.00[b]	1.324	1.329
V	0.0[b]	1.000	1.000
R	−0.78[b]	0.748	0.738
I	−1.60[b]	0.482	0.469
J	-2.22 ± 0.02	0.282	0.246
H	-2.55 ± 0.03	0.175	0.155
K	-2.744 ± 0.024	0.112	0.0885
L	-2.91 ± 0.03	0.058	0.045
M	-3.02 ± 0.03	0.023	0.033
N	−2.93	0.052	0.013
8.0 μm	−3.03	0.020 ± 0.003	
8.5	−2.96	0.043 ± 0.006	
9.0	−2.87	0.074 ± 0.011	
9.5	−2.83	0.087 ± 0.013	
10.0	−2.86	0.083 ± 0.012	
10.5	−2.87	0.074 ± 0.011	
11.0	−2.91	0.060 ± 0.009	
11.5	−2.95	0.047 ± 0.007	
12.0	−2.98	0.037 ± 0.006	
12.5	−3.00	0.030 ± 0.005	
13.0	−3.01	0.027 ± 0.004	

Extinción interestelar

Ejemplos:

- $A_V = 3.1E(B-V) = 4.3E(b-y)$
- $E(B-V)_0 = 1.35E(b-y)$
- $E(m_1) = -0.32E(b-y)$
- $E(c_1) = 0.2E(b-y)$

Extinción interestelar

Colores o índices libres de extinción (reddening free)

$I_L = I^1 - \frac{E(I^1)}{E(I^2)} I^2$

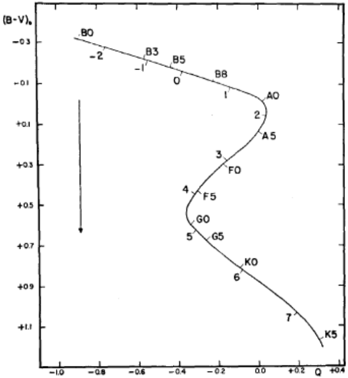
Demostración:

- $I_L = I_0^1 + E(I^1) - \frac{E(I^1)}{E(I^2)}(I_0^2 + E(I^2))$
- $I_L = I_0^1 + E(I^1) - \frac{E(I^1)}{E(I^2)} I_0^2 - \frac{E(I^1)}{E(I^2)} E(I^2)$
- $I_L = I_0^1 - \frac{E(I^1)}{E(I^2)}(I_0^2)$

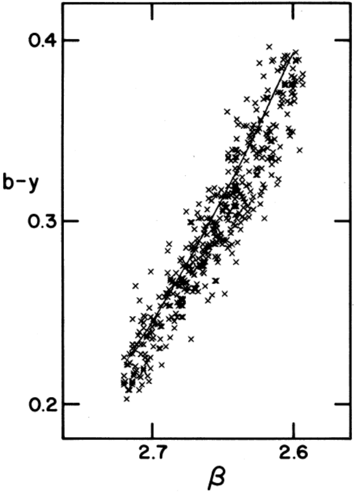
Extinción interestelar

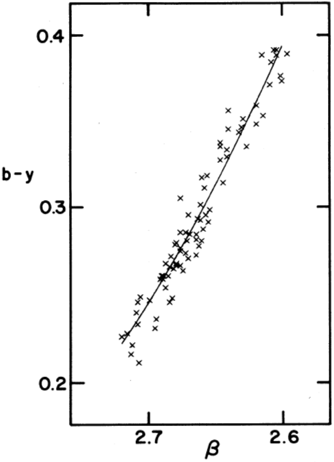
Parameters Q, X and intrinsic indices of the UBV system

Sp V	X	Q	$(B-V)_0$	$(U-B)_0$
O5	0.72	−0.92	−0.32	−1.15
O6	0.72	−0.91	−0.32	−1.14
O7	0.72	−0.91	−0.32	−1.14
O8	0.72	−0.91	−0.31	−1.13
O9	0.72	−0.90	−0.31	−1.12
O9.5	0.72	−0.88	−0.30	−1.10
B0	0.70	−0.86	−0.30	−1.08
B0.5	0.69	−0.81	−0.28	−1.01
B1	0.69	−0.74	−0.26	−0.93
B2	0.67	−0.69	−0.24	−0.86
B3	0.65	−0.57	−0.20	−0.71
B5	0.62	−0.44	−0.16	−0.56
B6	0.62	−0.39	−0.14	−0.49
B7	0.62	−0.33	−0.12	−0.42
B8	0.62	−0.24	−0.09	−0.30
B9	0.63	−0.15	−0.06	−0.19
B9.5	0.63	−0.08	−0.03	−0.10
A0	0.65	0.00	0.00	0.00

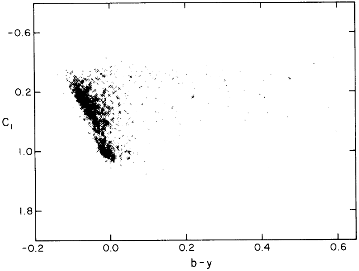


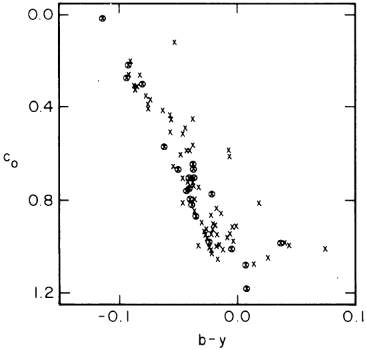
Extinción interestelar





Extinción interestelar





Temperatura efectiva

Ley de Stefan-Boltzmann

$F = \sigma T^4$

Definición de Luminosidad

$L = 4\pi R^2 F = 4\pi r^2 f$

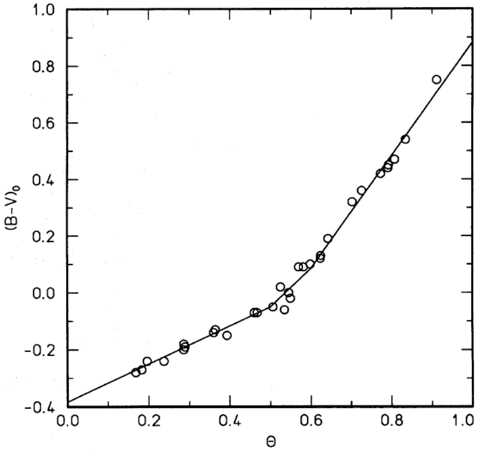
$L = 4\pi\sigma R^2 T_{eff}^4$

$\Rightarrow f = (\frac{R}{r})^2 \sigma T_{eff}^4$

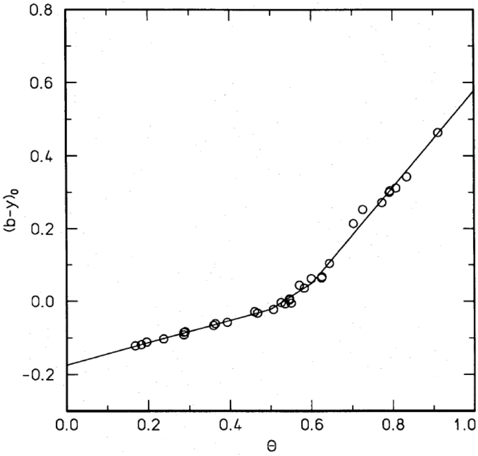
$\Rightarrow f = \theta^2 \sigma T_{eff}^4$

$\Theta = \frac{5040K}{T_{eff}}$

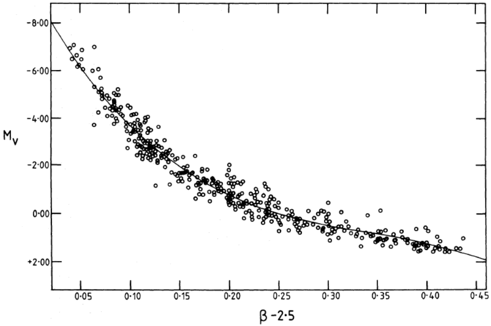
Temperatura efectiva



Temperatura efectiva



Luminosidad



Luminosidad

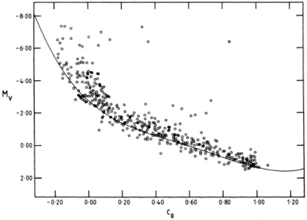


Figure 3. The H–R diagram using the distance moduli of the final calibration and showing the adopted ZAMS.

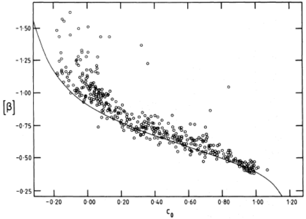
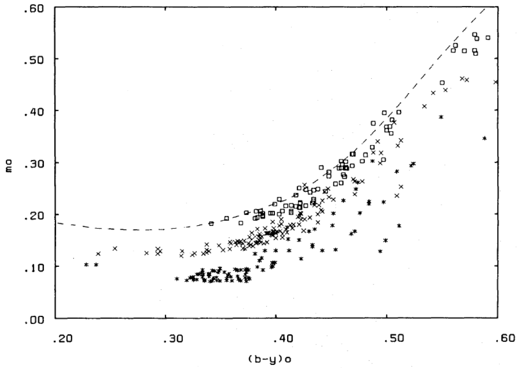
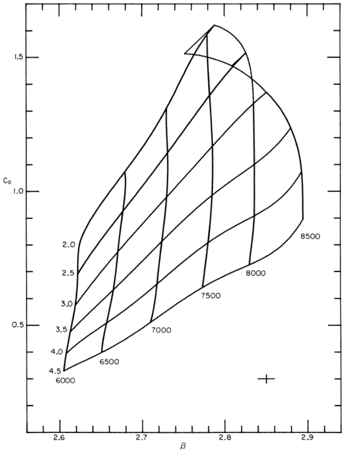


Figure 4. The H–R diagram obtained from the β index using the transformation $[\beta]=\log_{10}(\beta-2.515)$. The adopted ZAMS is shown.

Metalicidad



Red de calibración



Red de calibración