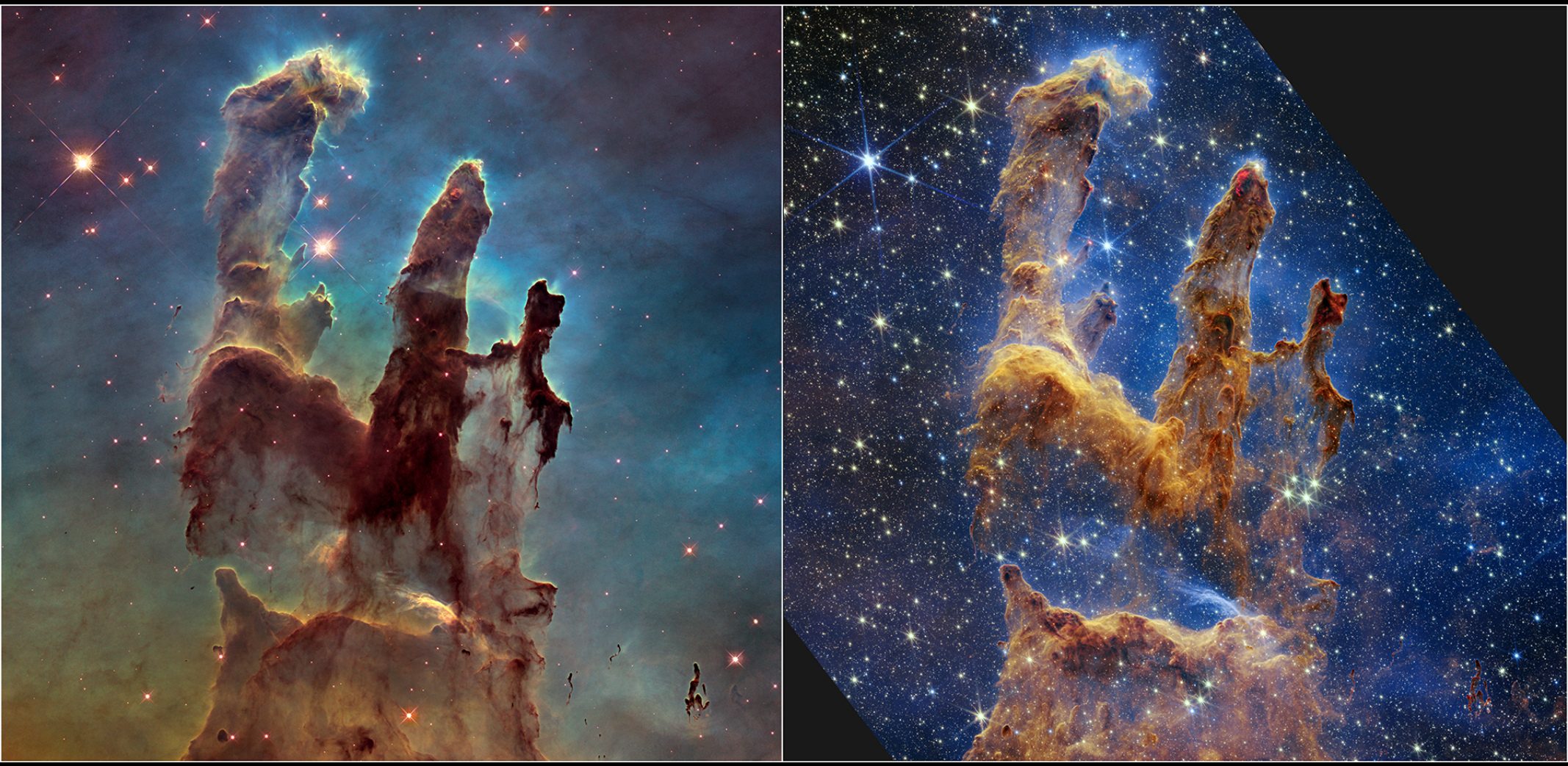
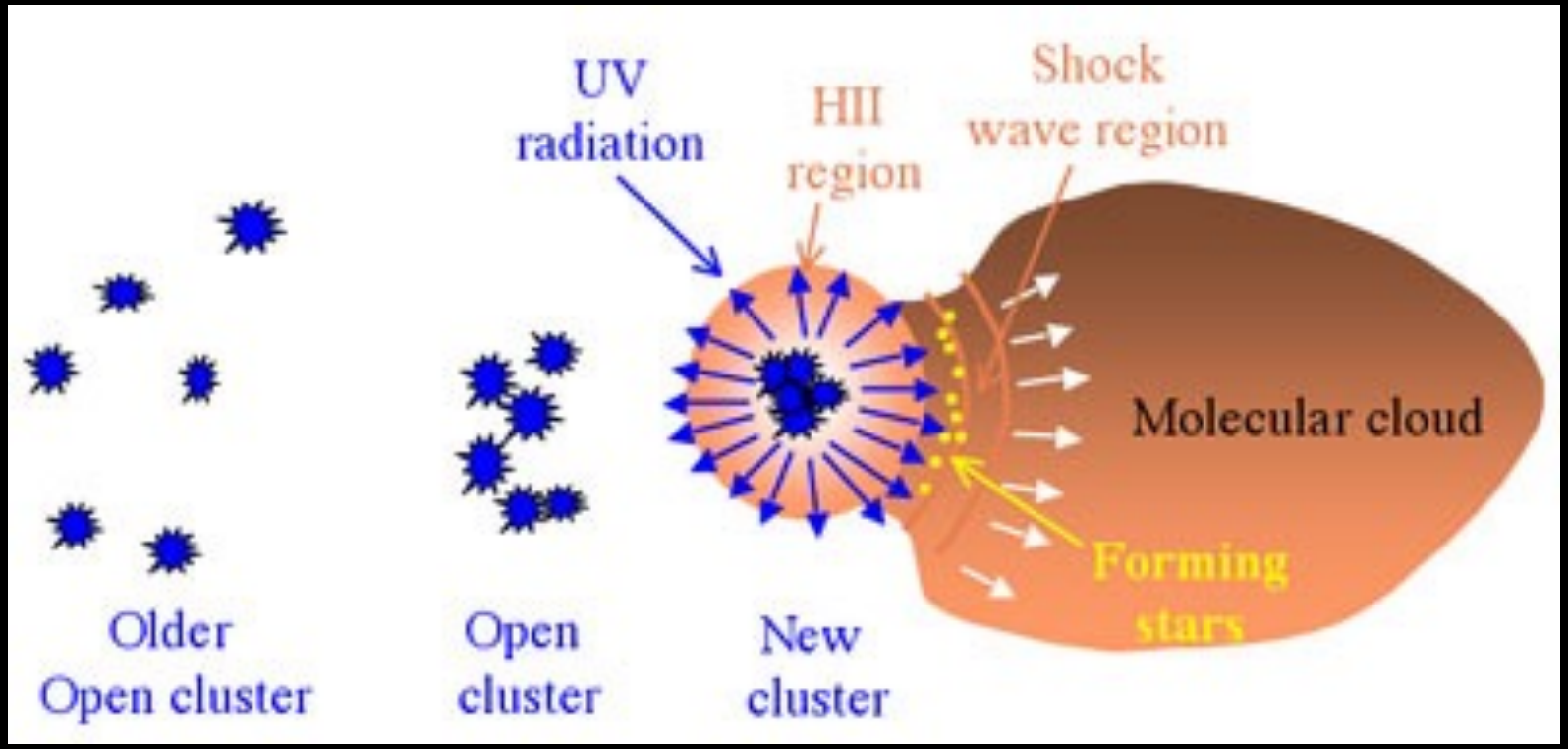
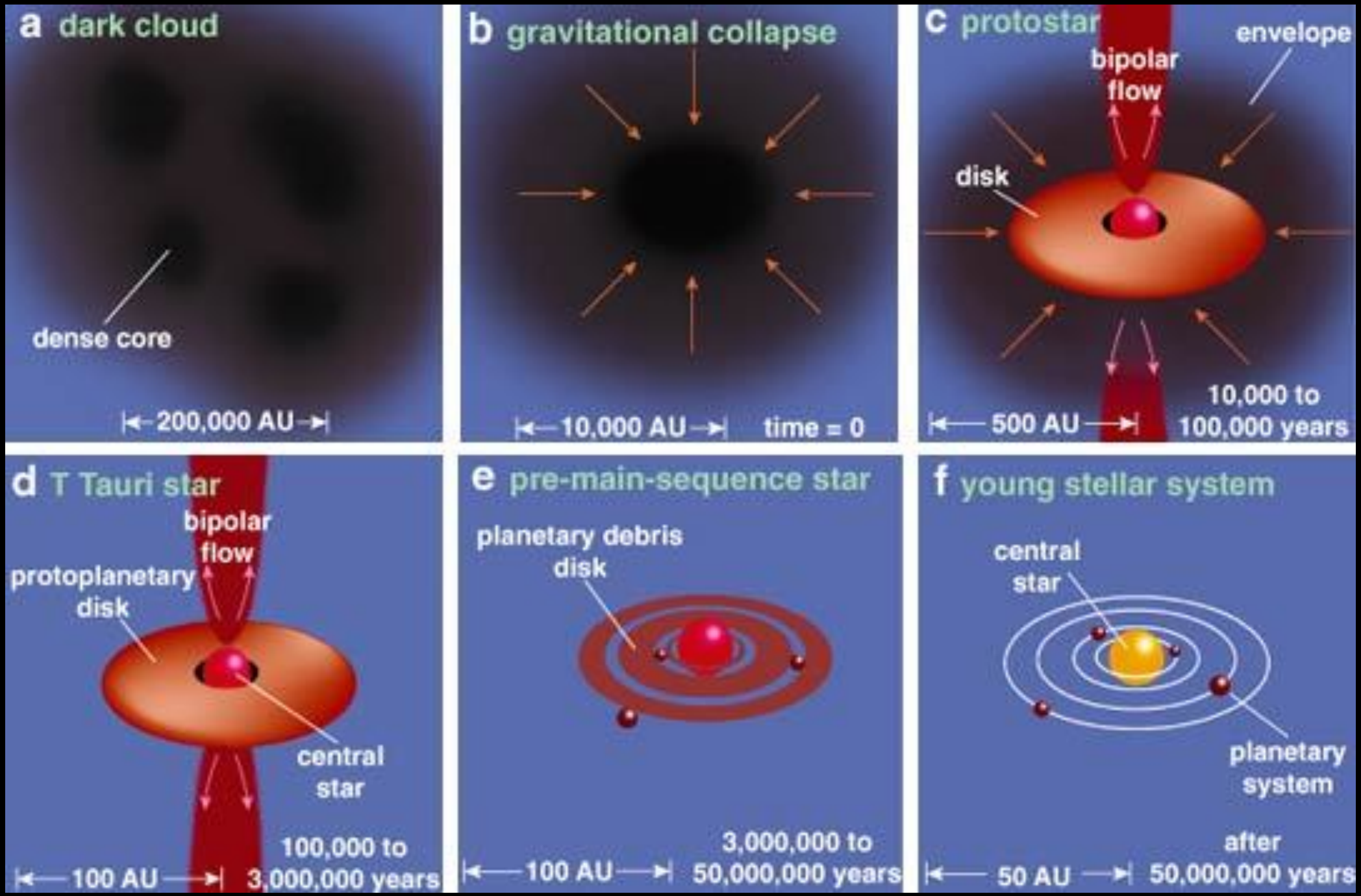
Structure and Evolution of Stars

Lecture 11

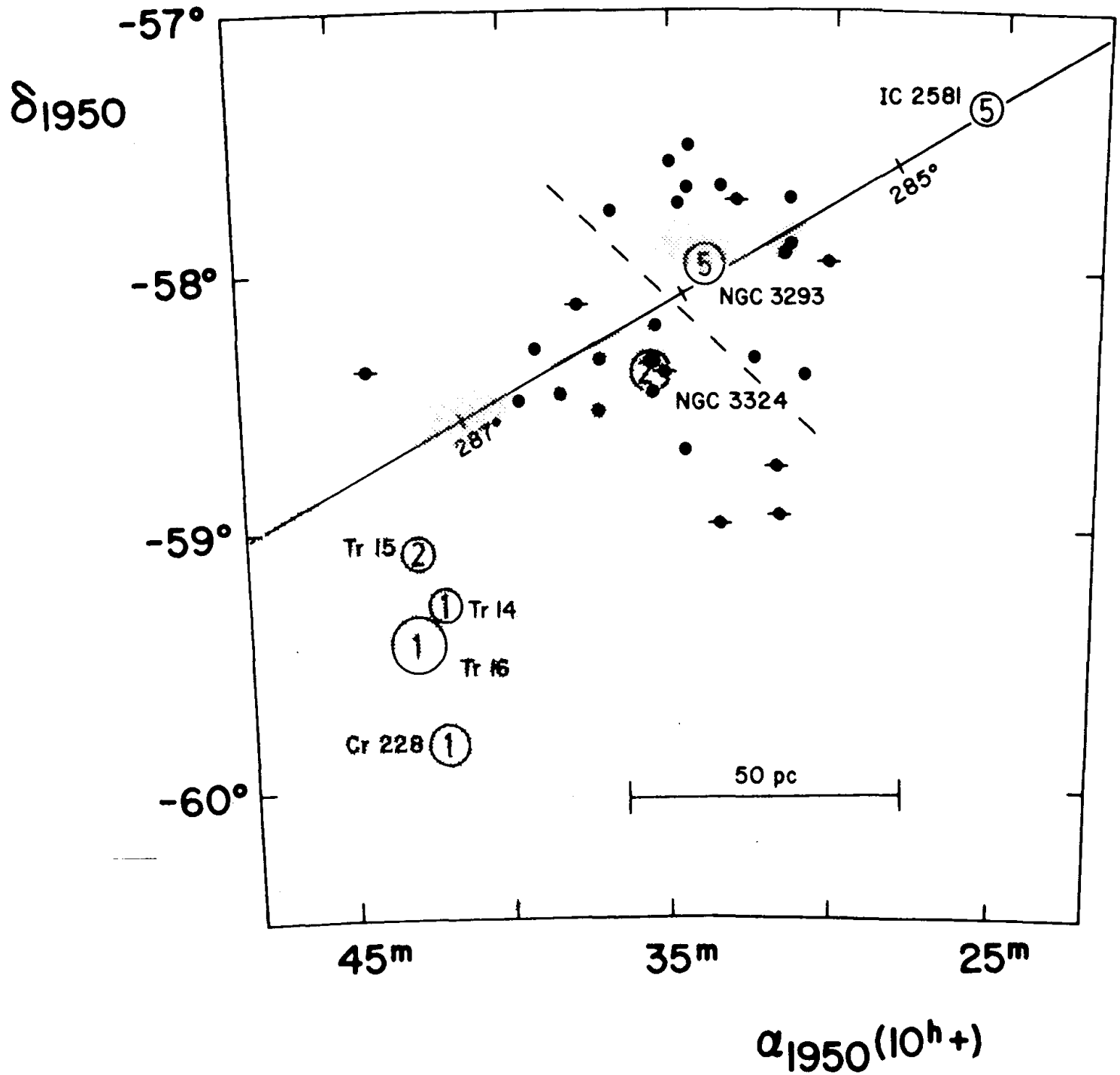


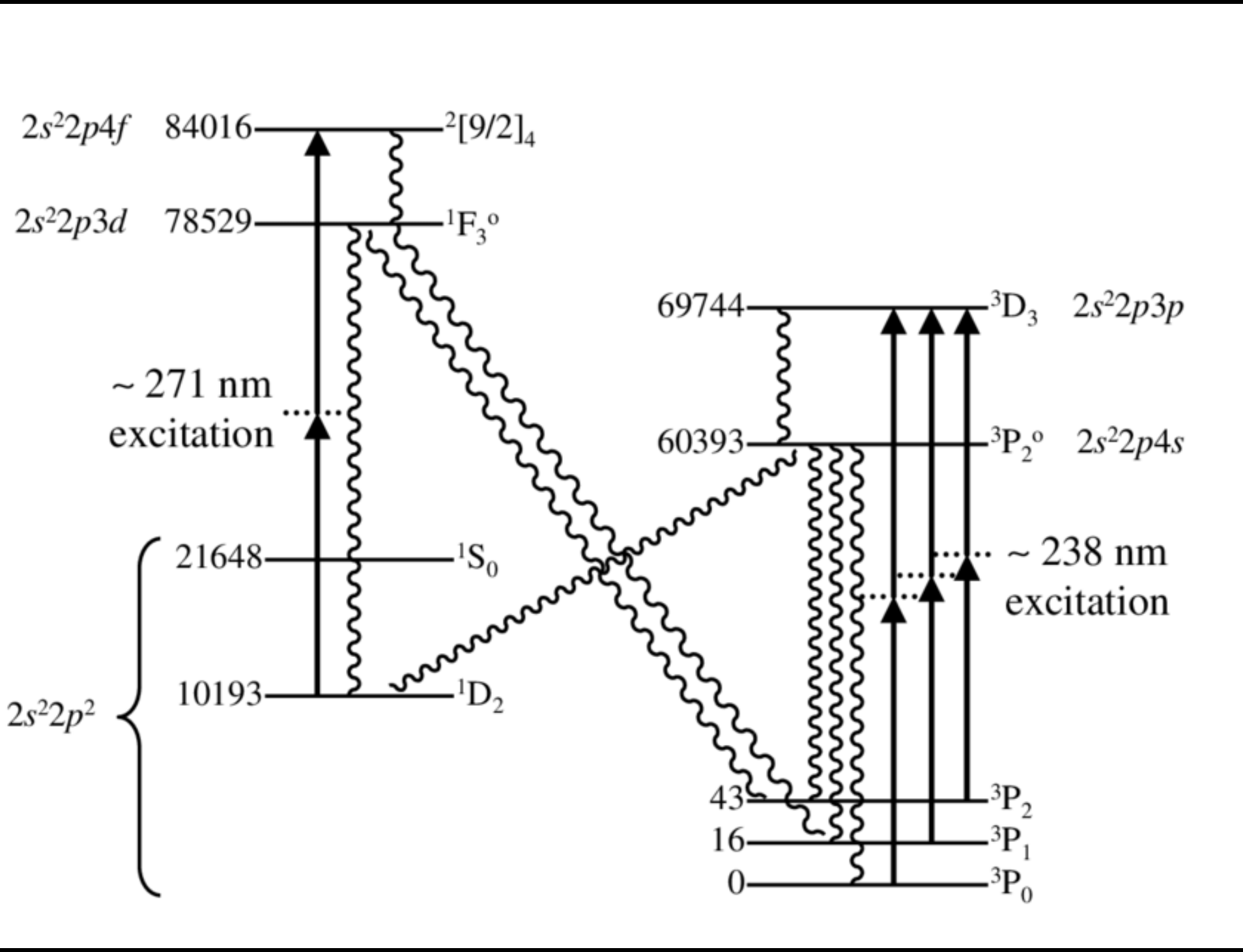

UV
radiation
HII
region
Shock
wave region
Molecular cloud
Forming
stars
Older
Open cluster
Open
cluster
New
cluster

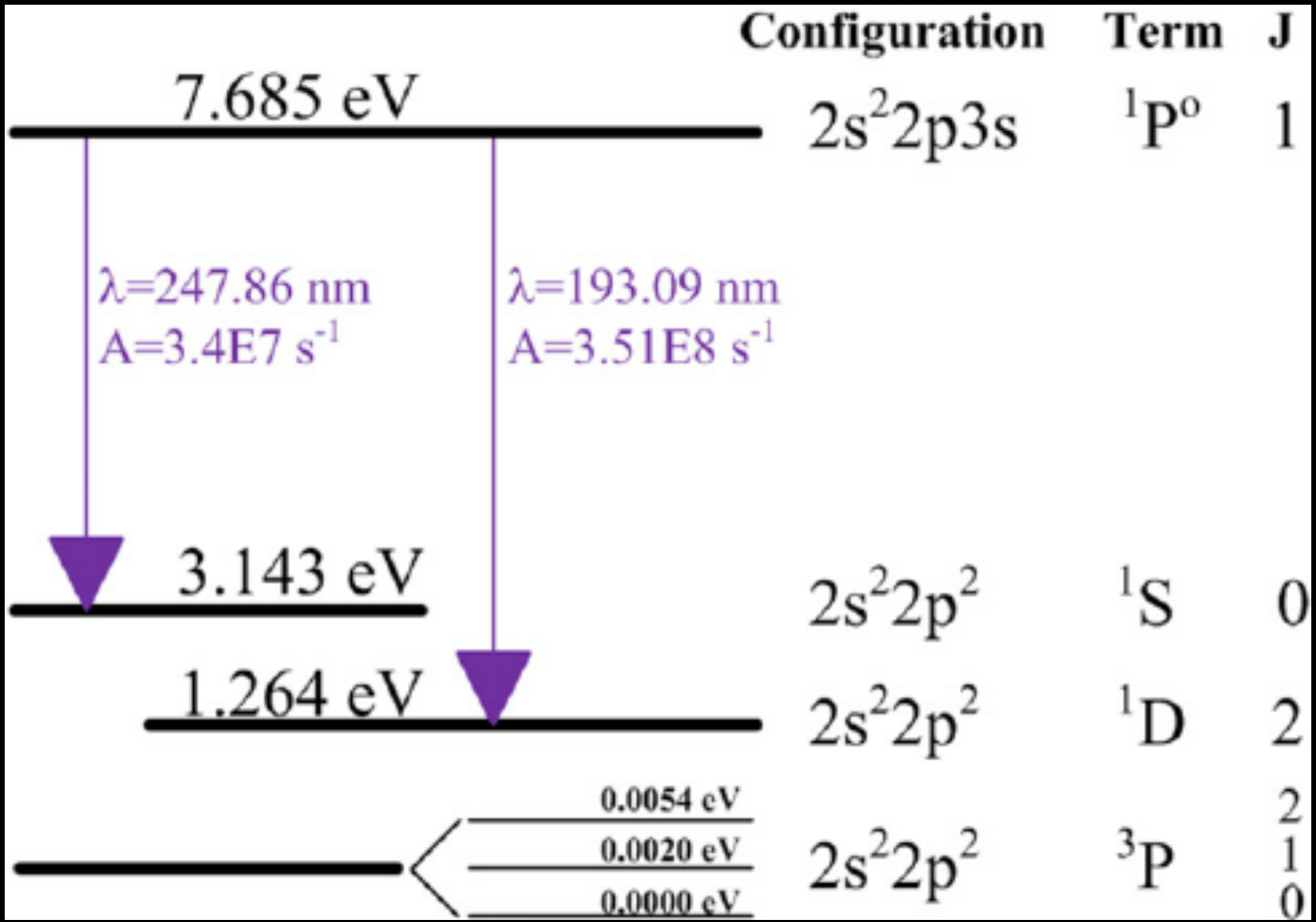

a dark cloud
dense core
200,000 AU
b gravitational collapse
10,000 AU
time = 0
c protostar
bipolar flow
envelope
disk
500 AU
10,000 to 100,000 years
d T Tauri star
bipolar flow
protoplanetary disk
central star
100 AU
100,000 to 3,000,000 years
e pre-main-sequence star
planetary debris disk
100 AU
3,000,000 to 50,000,000 years
f young stellar system
central star
planetary system
50 AU
after 50,000,000 years

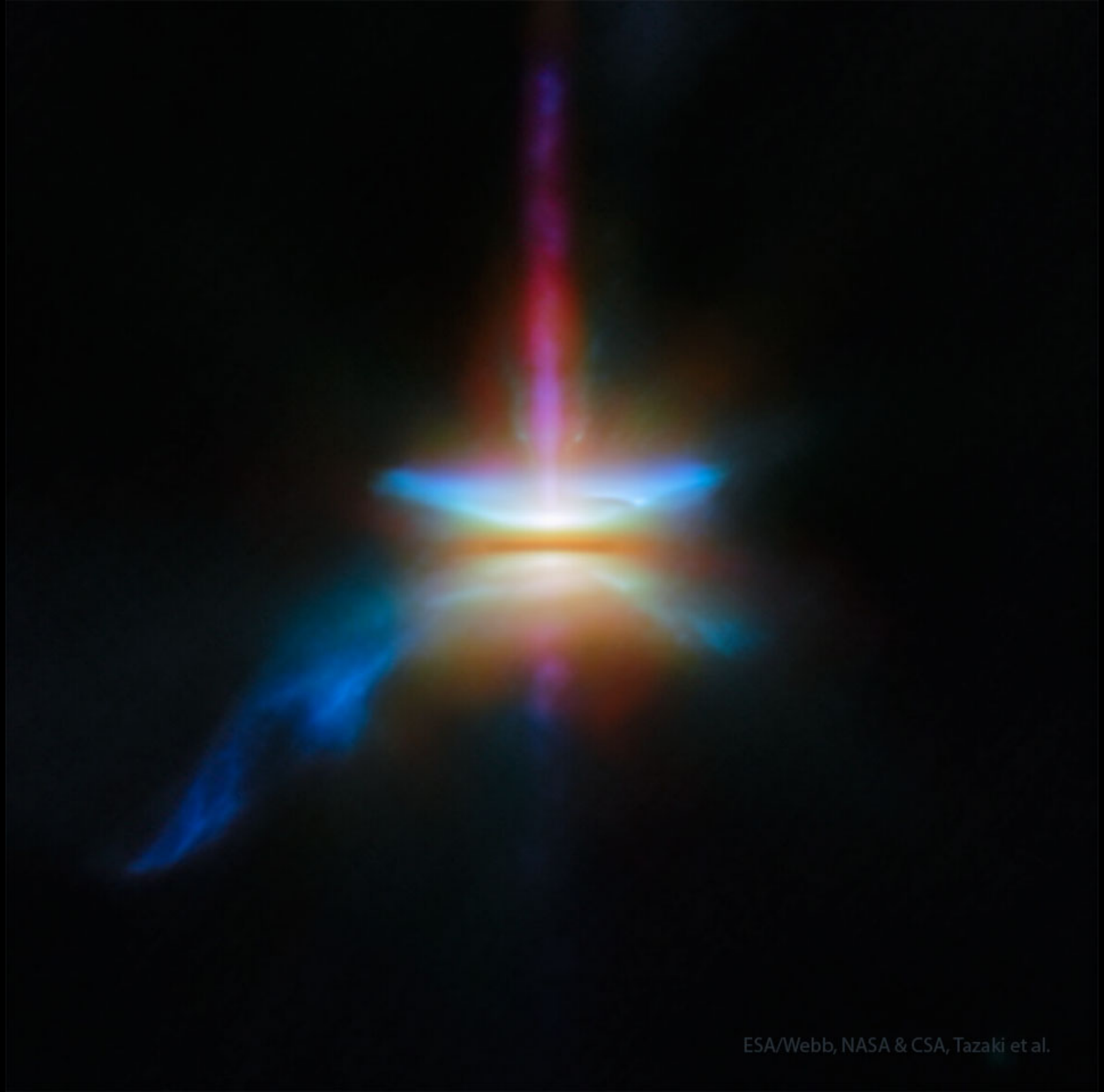

SCIENCEphotoLIBRARY

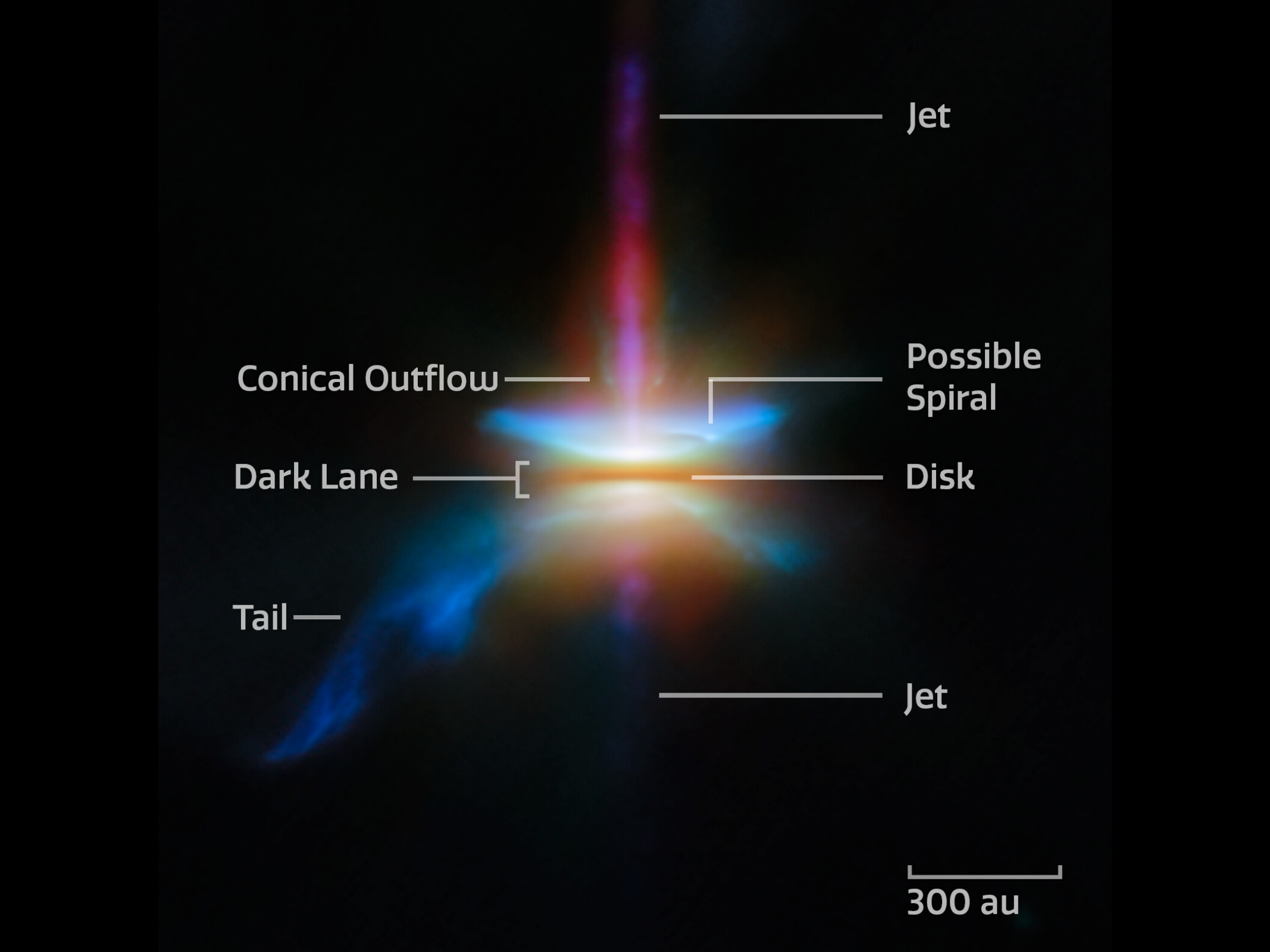
ESA/Hubble & NASA, J. Dalcanton
Dark Energy Survey/DOE/FNAL/DECam/CTIO/NOIRLab/NSF/AURA,

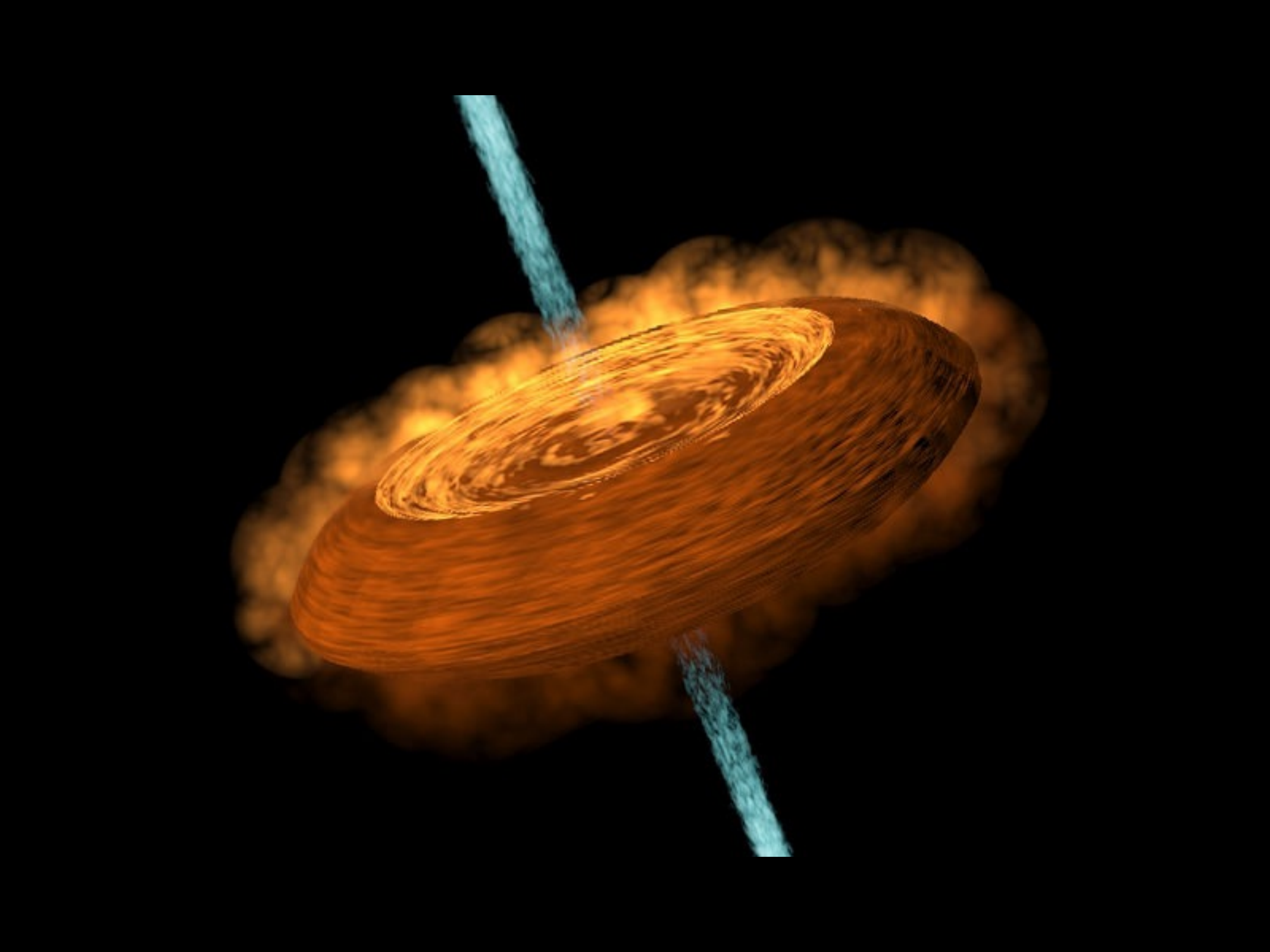

-57°
-58°
-59°
-60°
δ1950
IC 2581
5
285°
5
NGC 3293
NGC 3324
287°
Tr 15
2
1
Tr 14
1
Tr 16
Cr 228
1
50 pc
45m
35m
25m
α1950(10h+)


$2s^2 2p 4f$ 84016 $^2[9/2]_4$
$2s^2 2p 3d$ 78529 $^1F_3{}^o$
~ 271 nm excitation
21648 $^1S_0$
10193 $^1D_2$
$2s^2 2p^2$
69744 $^3D_3$ $2s^2 2p 3p$
60393 $^3P_2{}^o$ $2s^2 2p 4s$
~ 238 nm excitation
43 $^3P_2$
16 $^3P_1$
0 $^3P_0$


Configuration
Term
J
7.685 eV
2s²2p3s
¹Pº
1
λ=247.86 nm
A=3.4E7 s⁻¹
λ=193.09 nm
A=3.51E8 s⁻¹
3.143 eV
2s²2p²
¹S
0
1.264 eV
2s²2p²
¹D
2
0.0054 eV
0.0020 eV
0.0000 eV
2s²2p²
³P
2
1
0


ESA/Webb, NASA & CSA, Tazaki et al.


Jet
Conical Outflow
Possible Spiral
Dark Lane
Disk
Tail
Jet
300 au



JAMES WEBB SPACE TELESCOPE

L1527 IRS | IRAS 04368+2557

NIRCam Filters | F200W F335M F444W F470N


ESA/Webb, NASA, CSA, Tom Ray (Dublin)

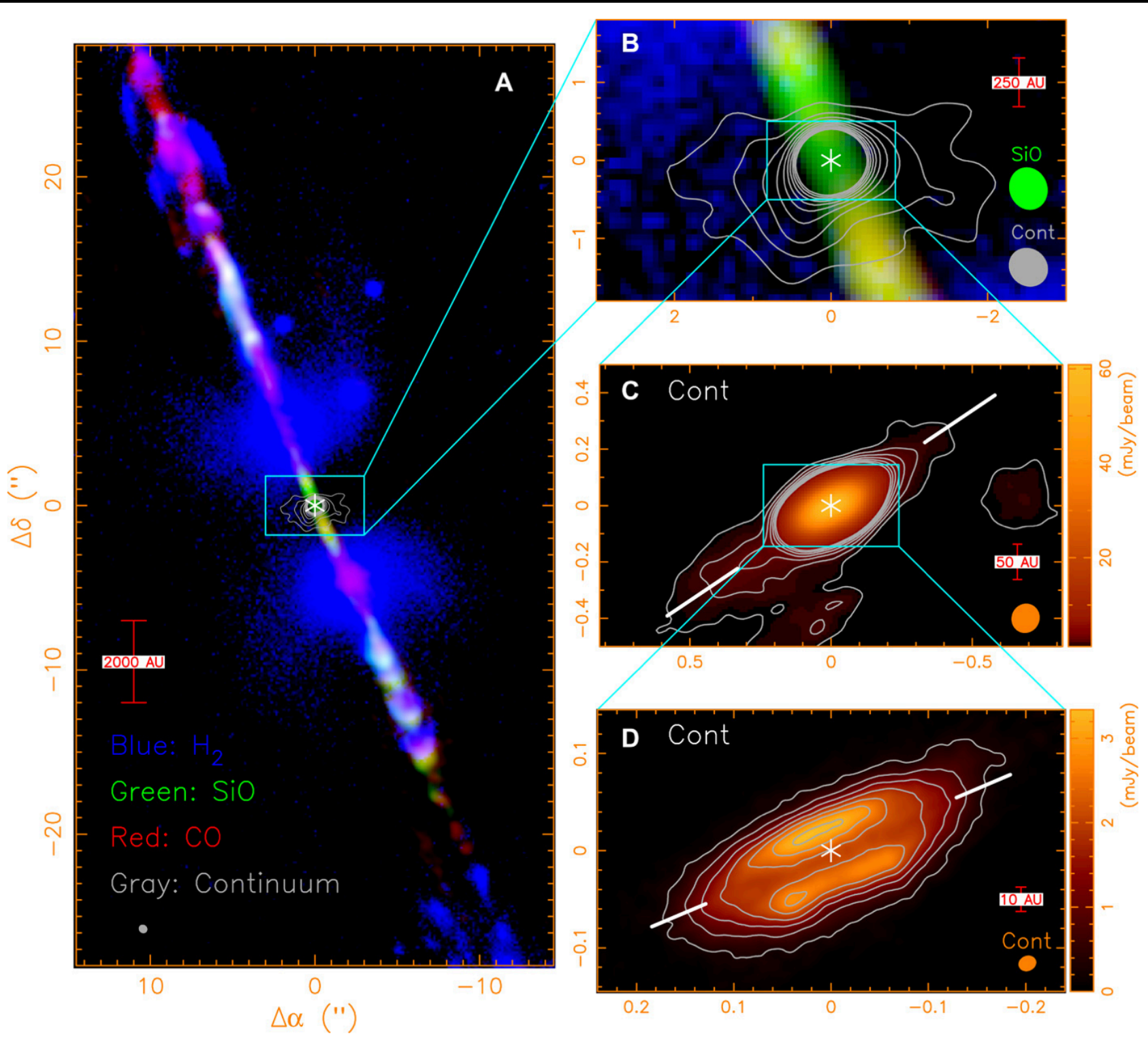
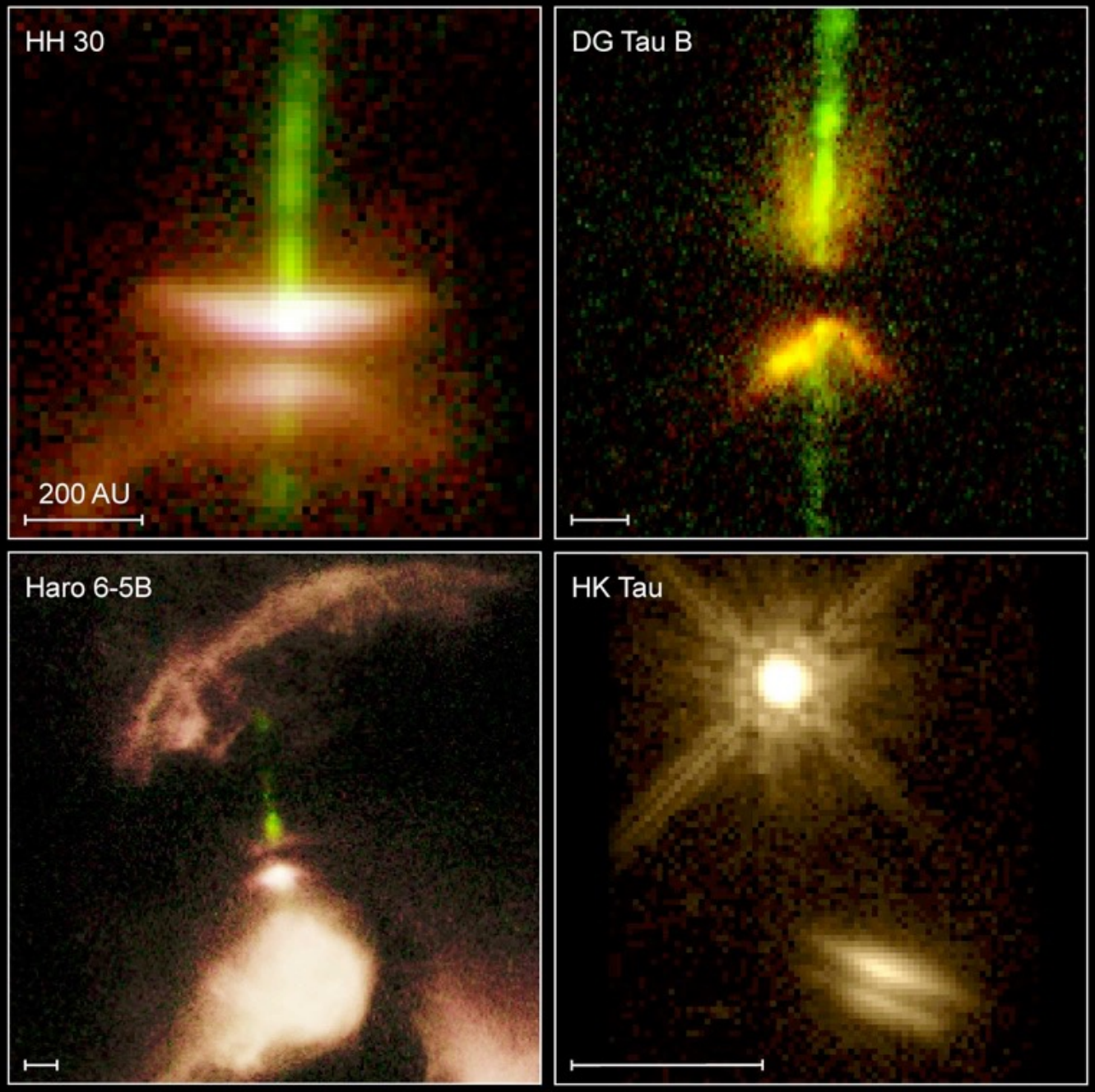


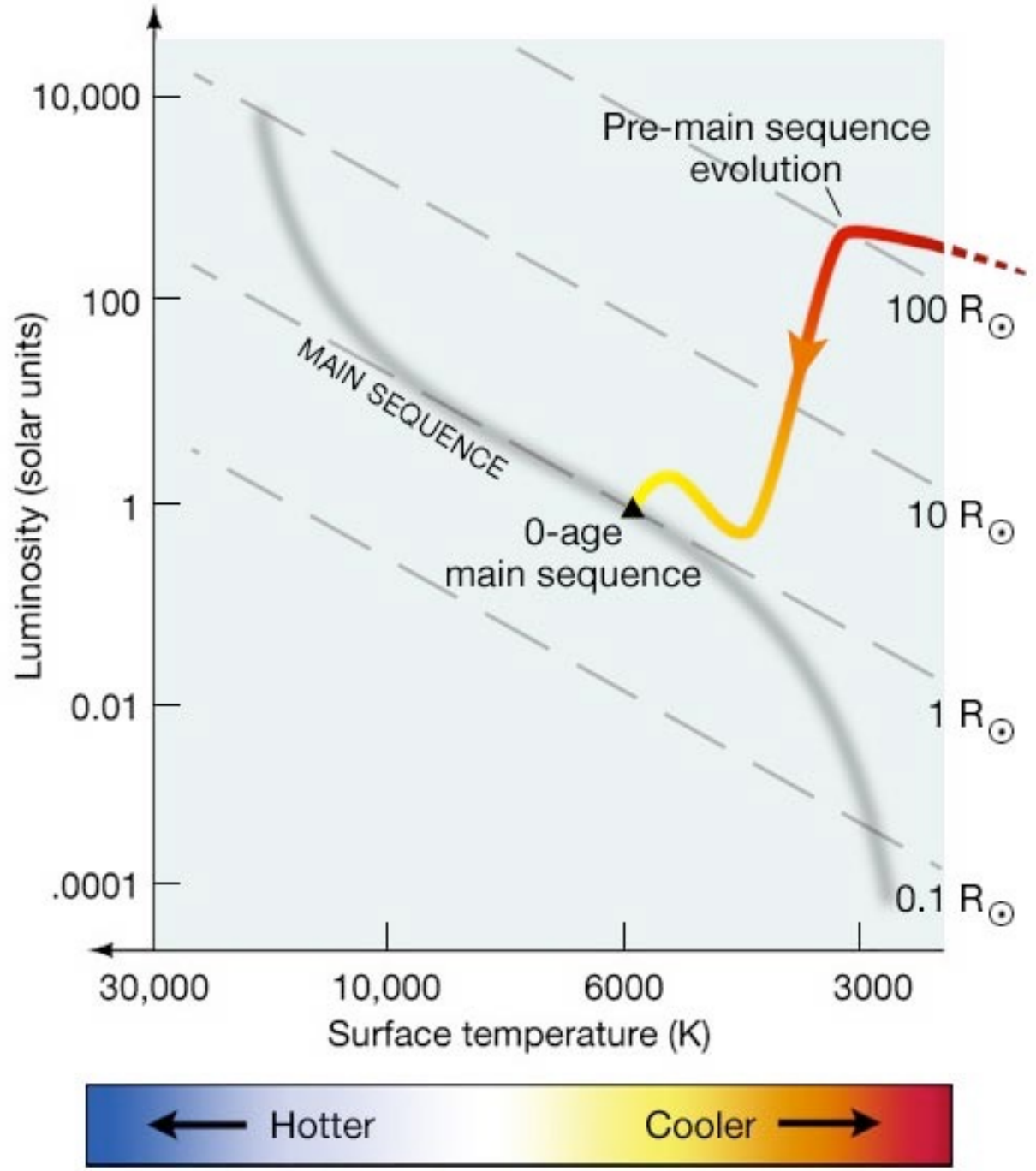
Fig. 1 ALMA maps of the jet, envelope, and disk in the HH 212 system.

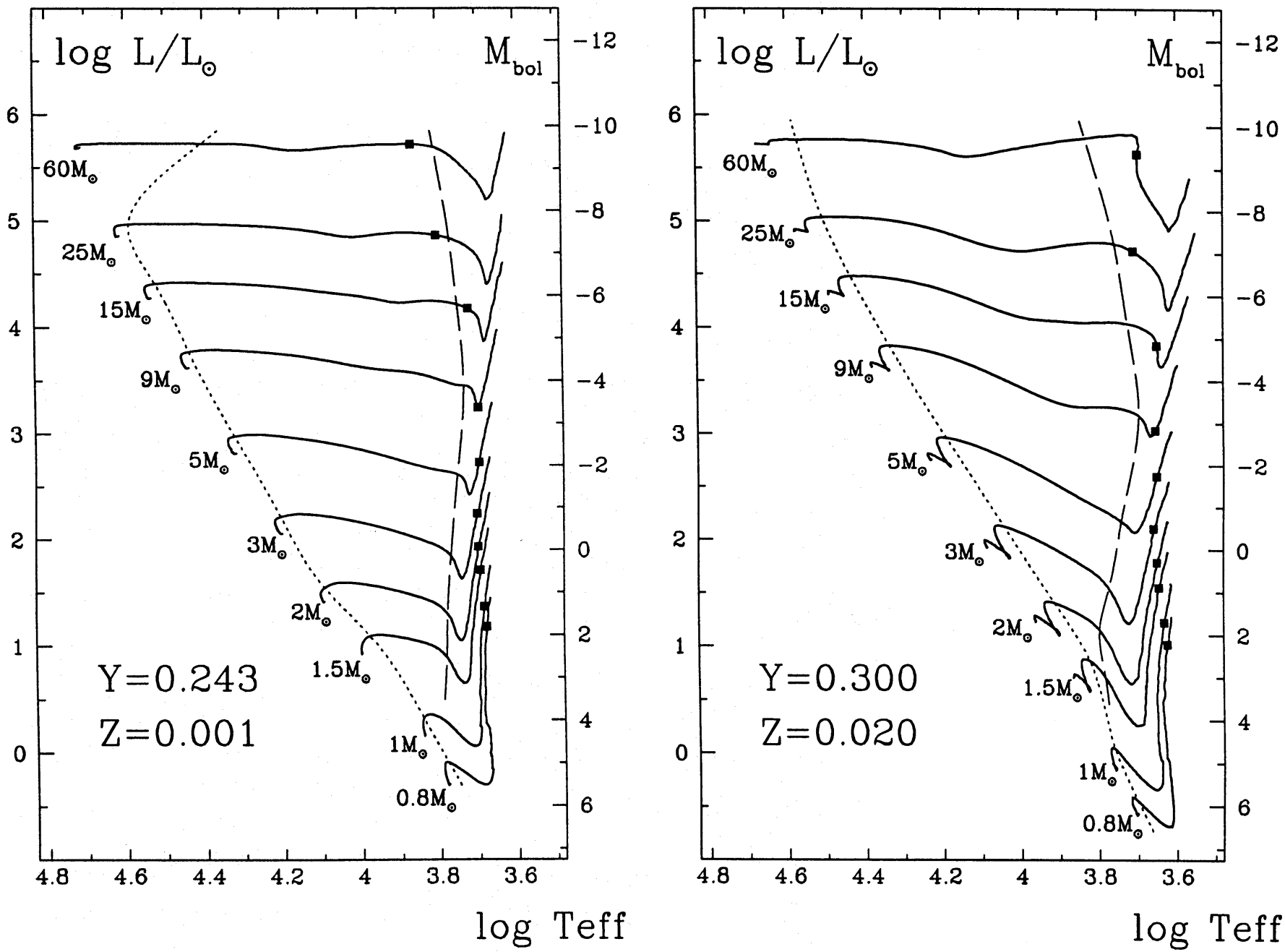


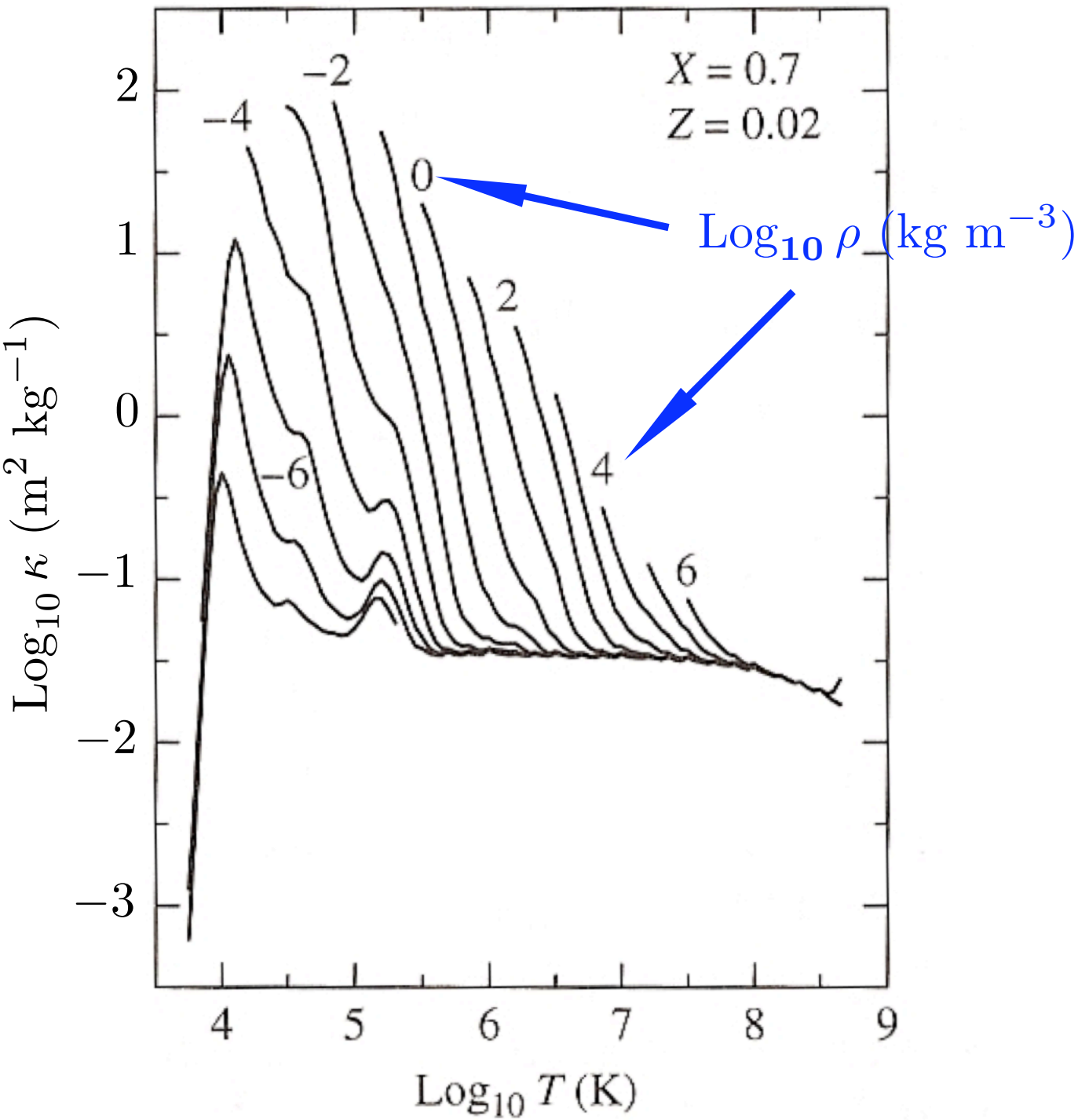
Disks around Young Stars

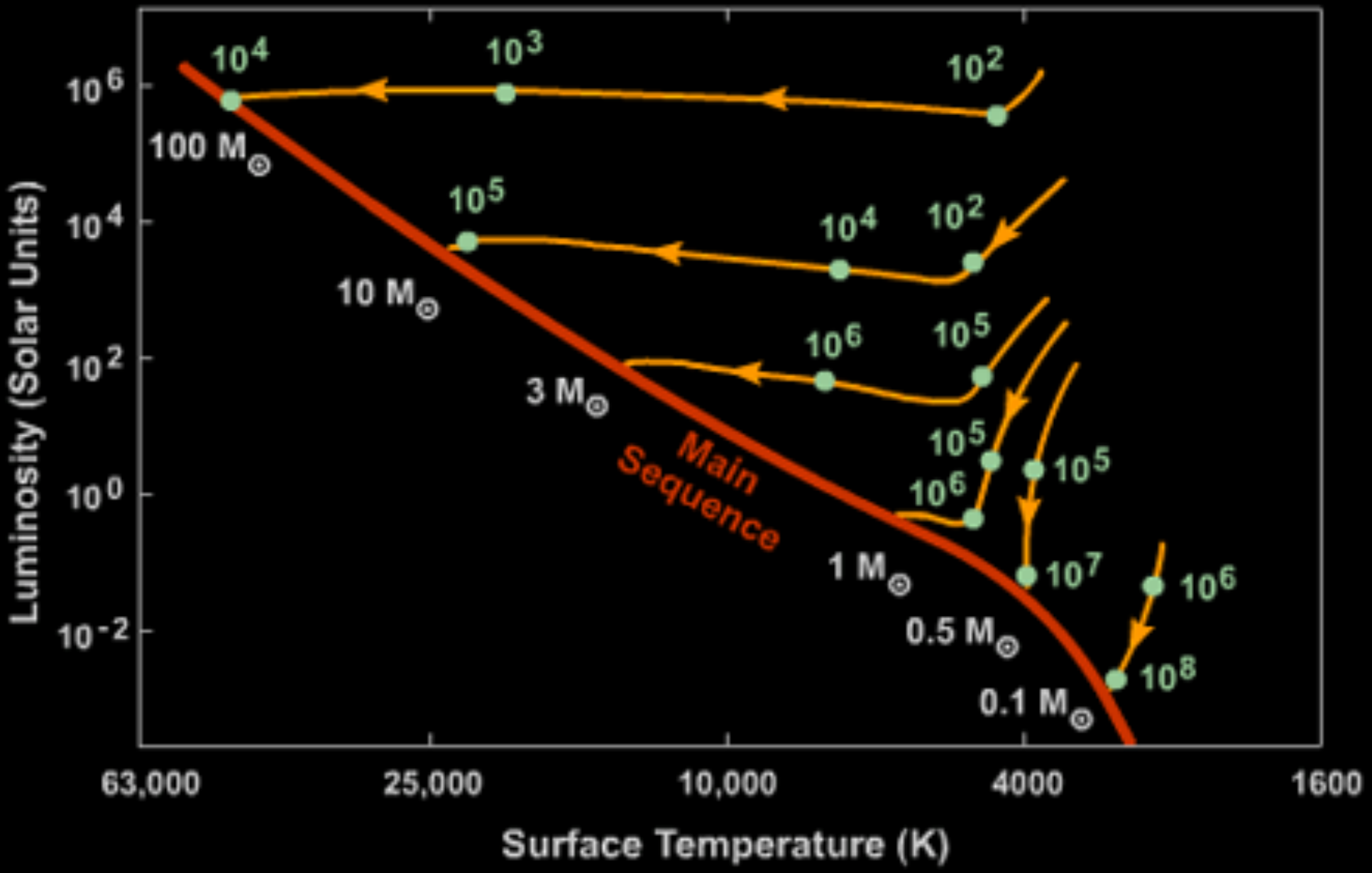
Hubble Space Telescope • WFPC2

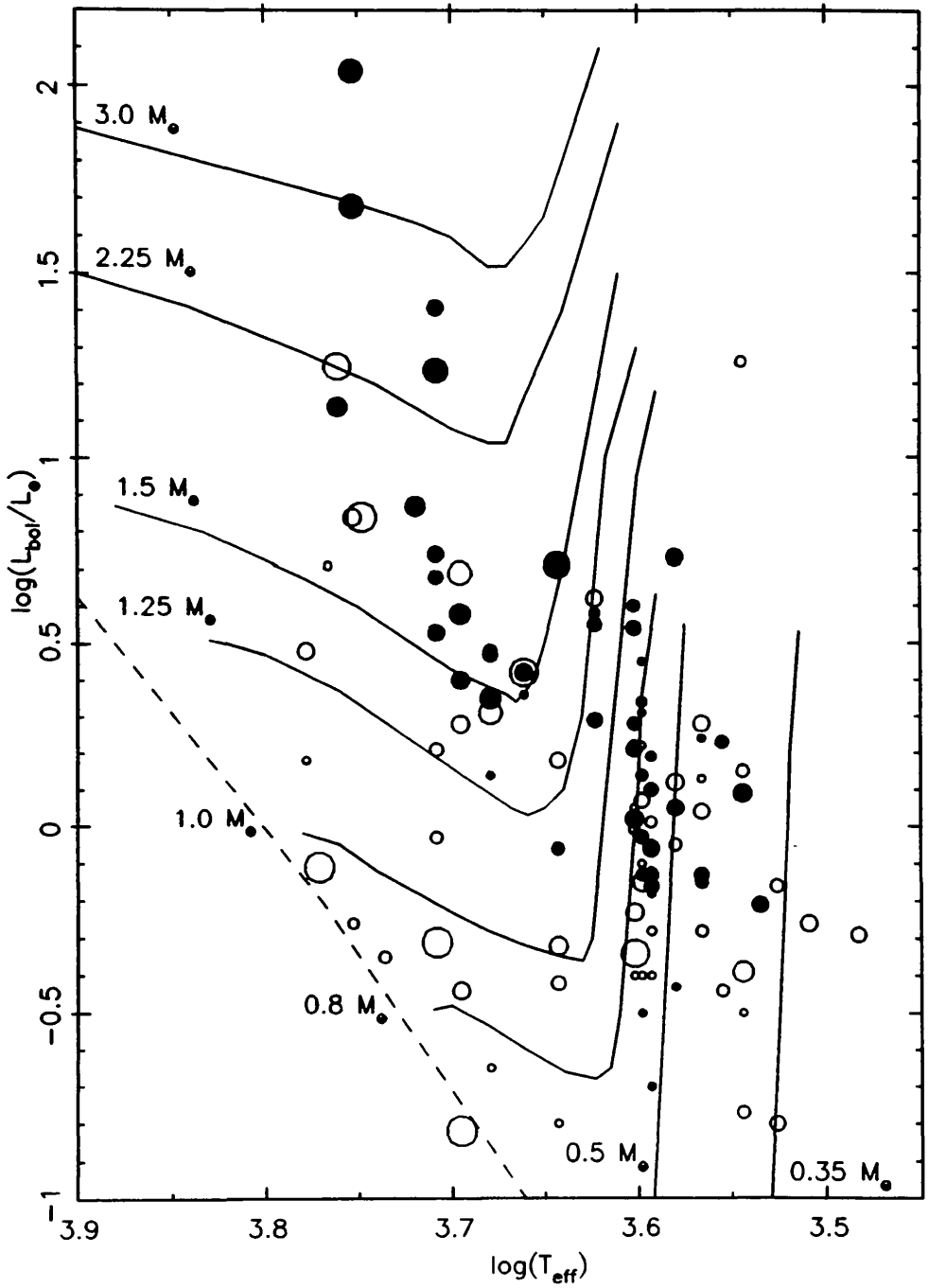
PRC99-05b • STScI OPO • C. Burrows and J. Krist (STScI), K. Stapelfeldt (JPL) and NASA

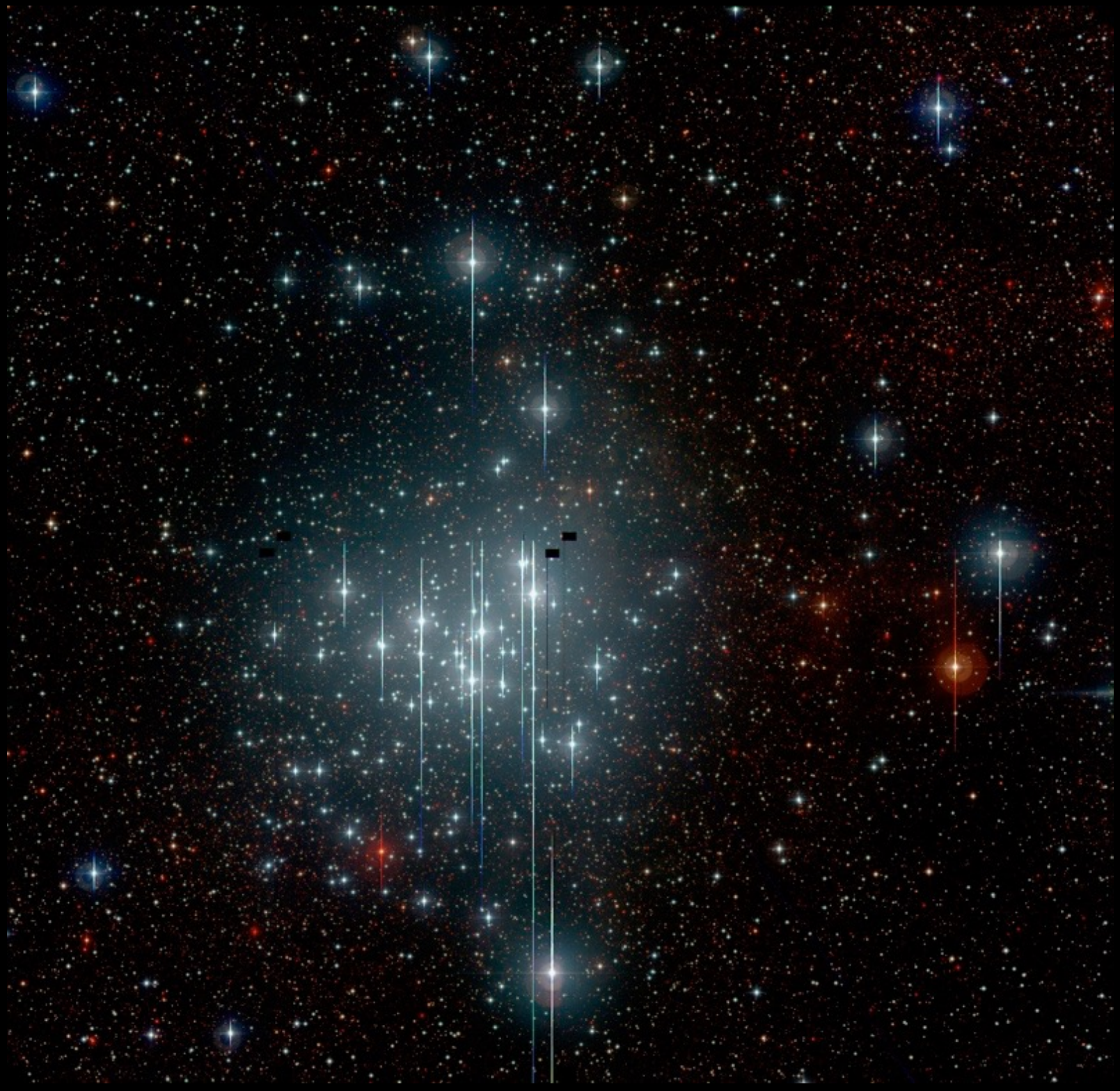

10,000
100
1
0.01
.0001
Luminosity (solar units)
Pre-main sequence
evolution
100 R⊙
MAIN SEQUENCE
0-age
main sequence
10 R⊙
1 R⊙
0.1 R⊙
30,000
10,000
6000
3000
Surface temperature (K)
Hotter
Cooler


log L/L⊙
M_bol
-12
-10
-8
-6
-4
-2
0
2
4
6
60M⊙
25M⊙
15M⊙
9M⊙
5M⊙
3M⊙
2M⊙
1.5M⊙
1M⊙
0.8M⊙
Y=0.243
Z=0.001
4.8
4.6
4.4
4.2
4
3.8
3.6
log Teff
log L/L⊙
M_bol
60M⊙
25M⊙
15M⊙
9M⊙
5M⊙
3M⊙
2M⊙
1.5M⊙
1M⊙
0.8M⊙
Y=0.300
Z=0.020
log Teff


X = 0.7
Z = 0.02
−2
−4
0
2
4
6
−6
Log10 ρ (kg m−3)
Log10 κ (m2 kg−1)
Log10 T (K)
2
1
0
−1
−2
−3
4
5
6
7
8
9


Luminosity (Solar Units)
10^6
10^4
10^2
10^0
10^{-2}
10^4
10^3
10^2
100 $M_\odot$
10^5
10^4
10^2
10 $M_\odot$
10^6
10^5
3 $M_\odot$
Main Sequence
10^5
10^6
10^5
1 $M_\odot$
10^7
10^6
0.5 $M_\odot$
10^8
0.1 $M_\odot$
63,000
25,000
10,000
4000
1600
Surface Temperature (K)


3.0 M⊙
2.25 M⊙
1.5 M⊙
1.25 M⊙
1.0 M⊙
0.8 M⊙
0.5 M⊙
0.35 M⊙
log(L_bol/L⊙)
log(T_eff)
2
1.5
1
0.5
0
−0.5
−1
3.9
3.8
3.7
3.6
3.5



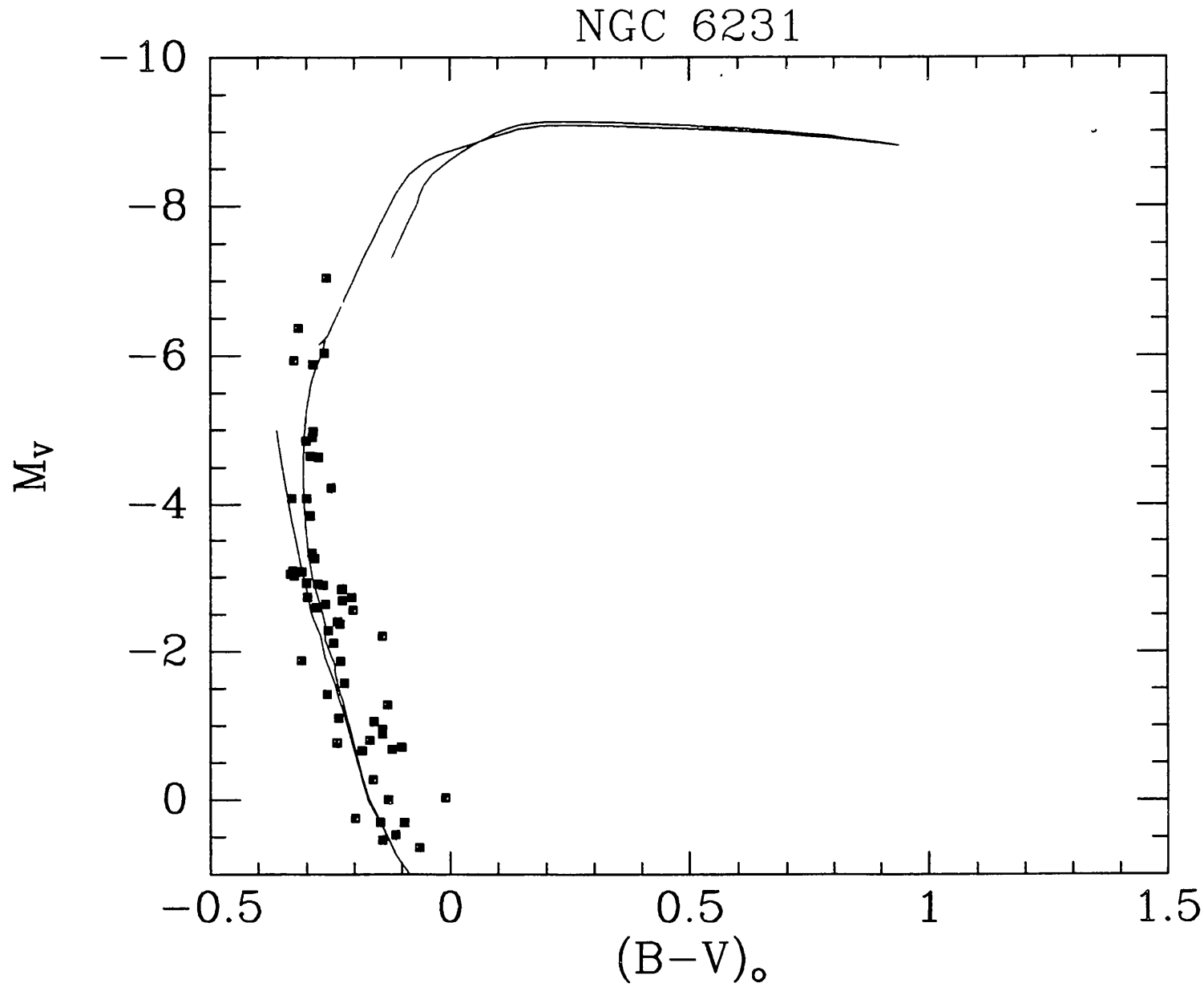
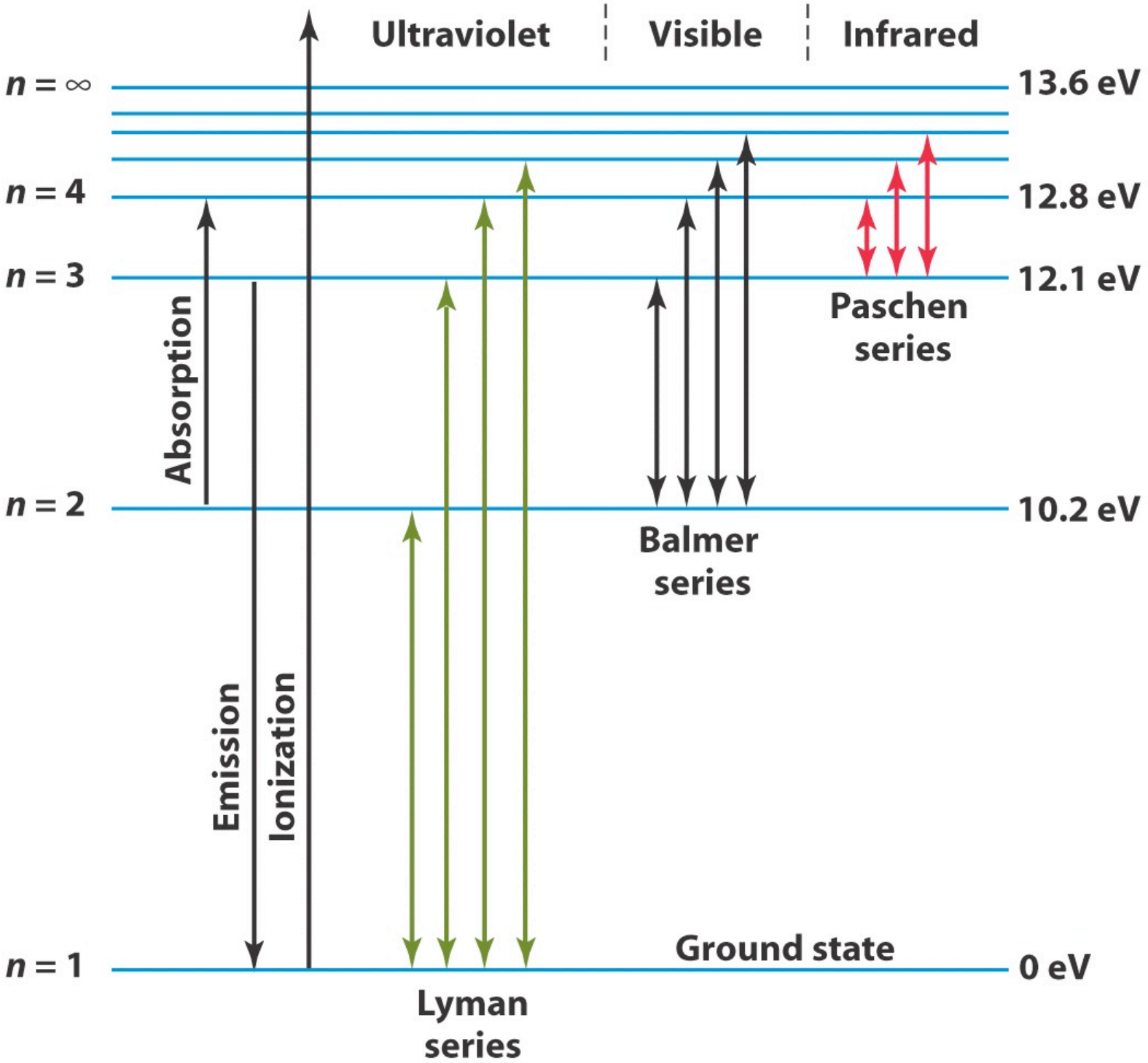
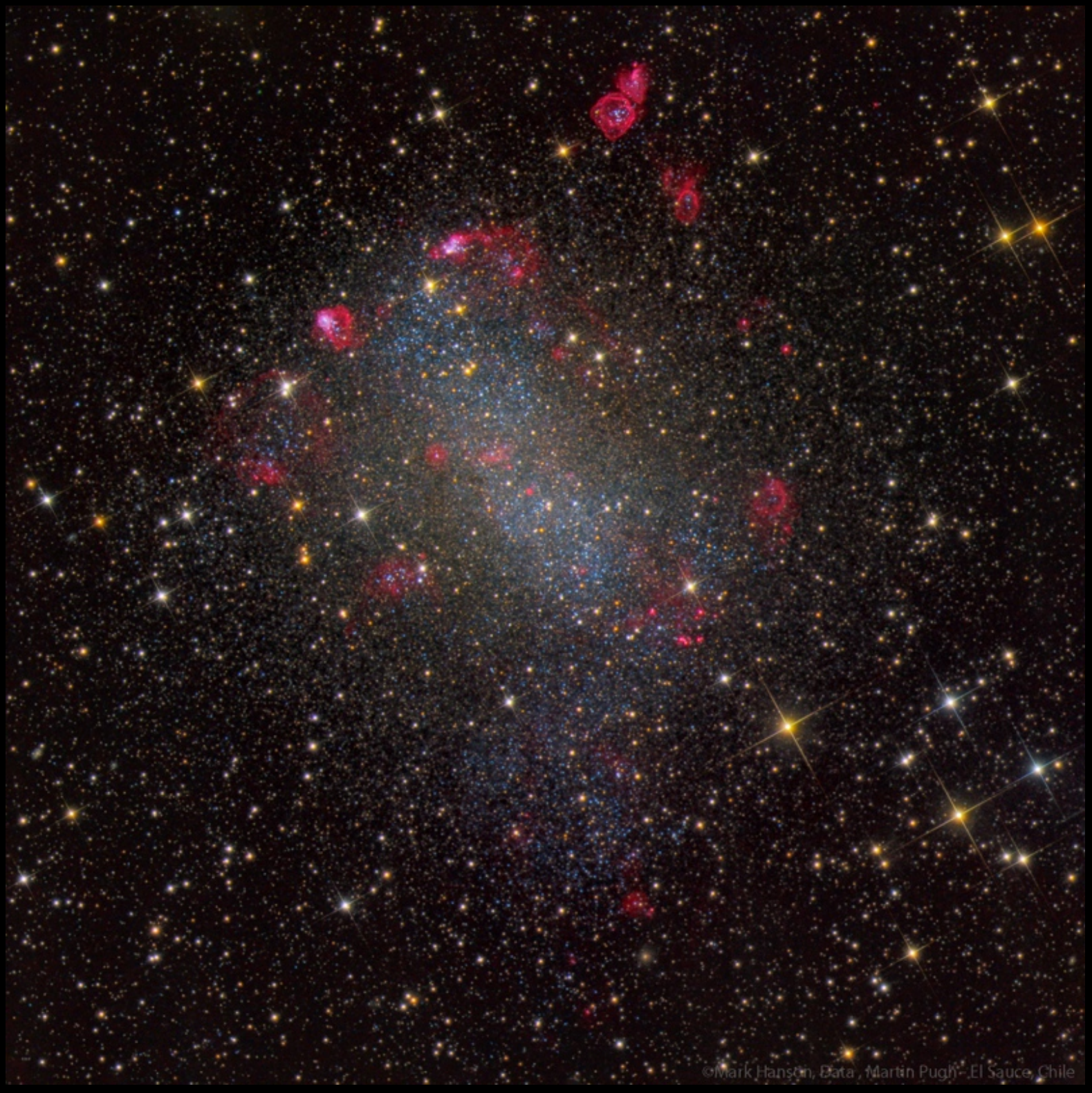
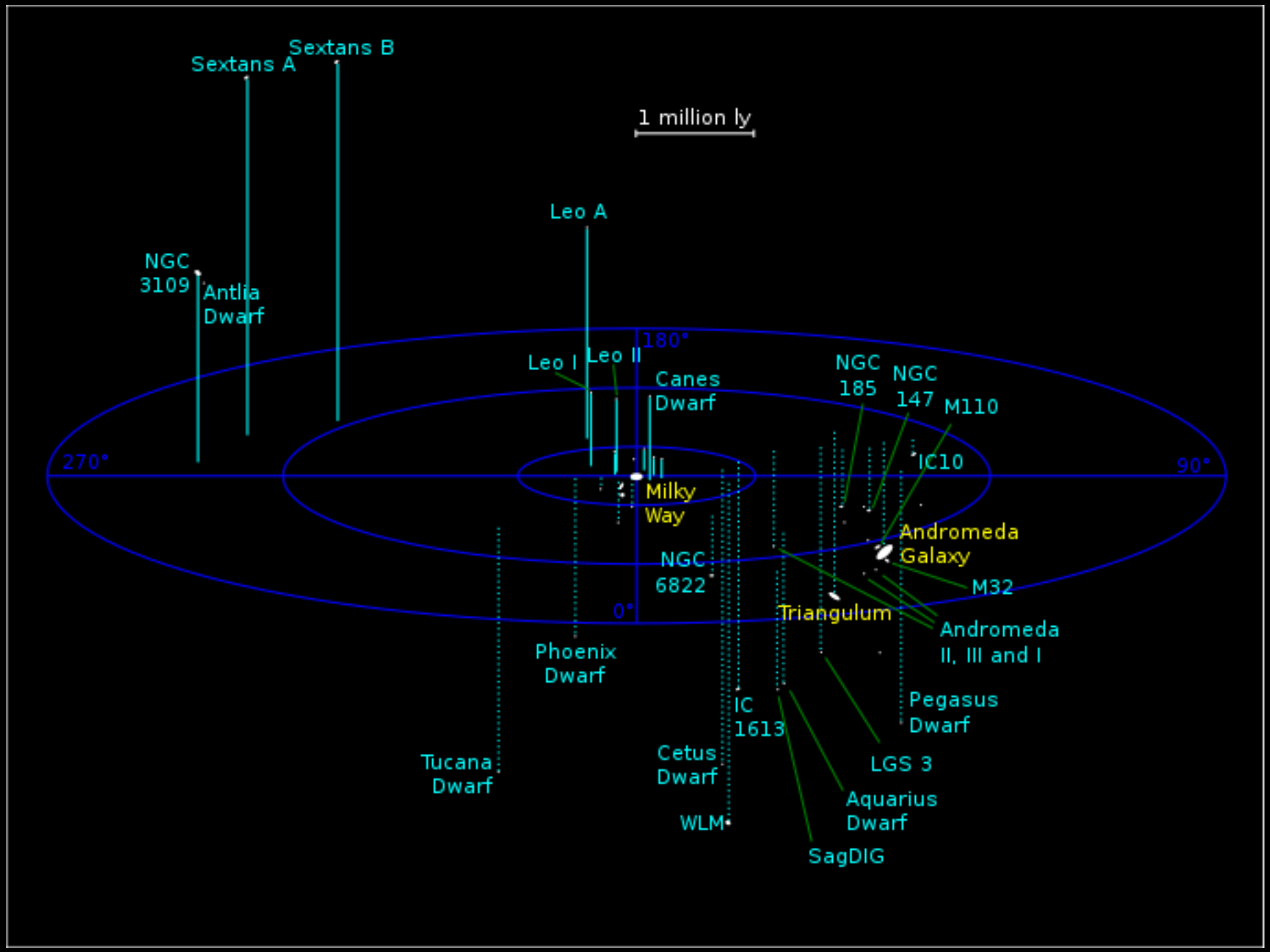


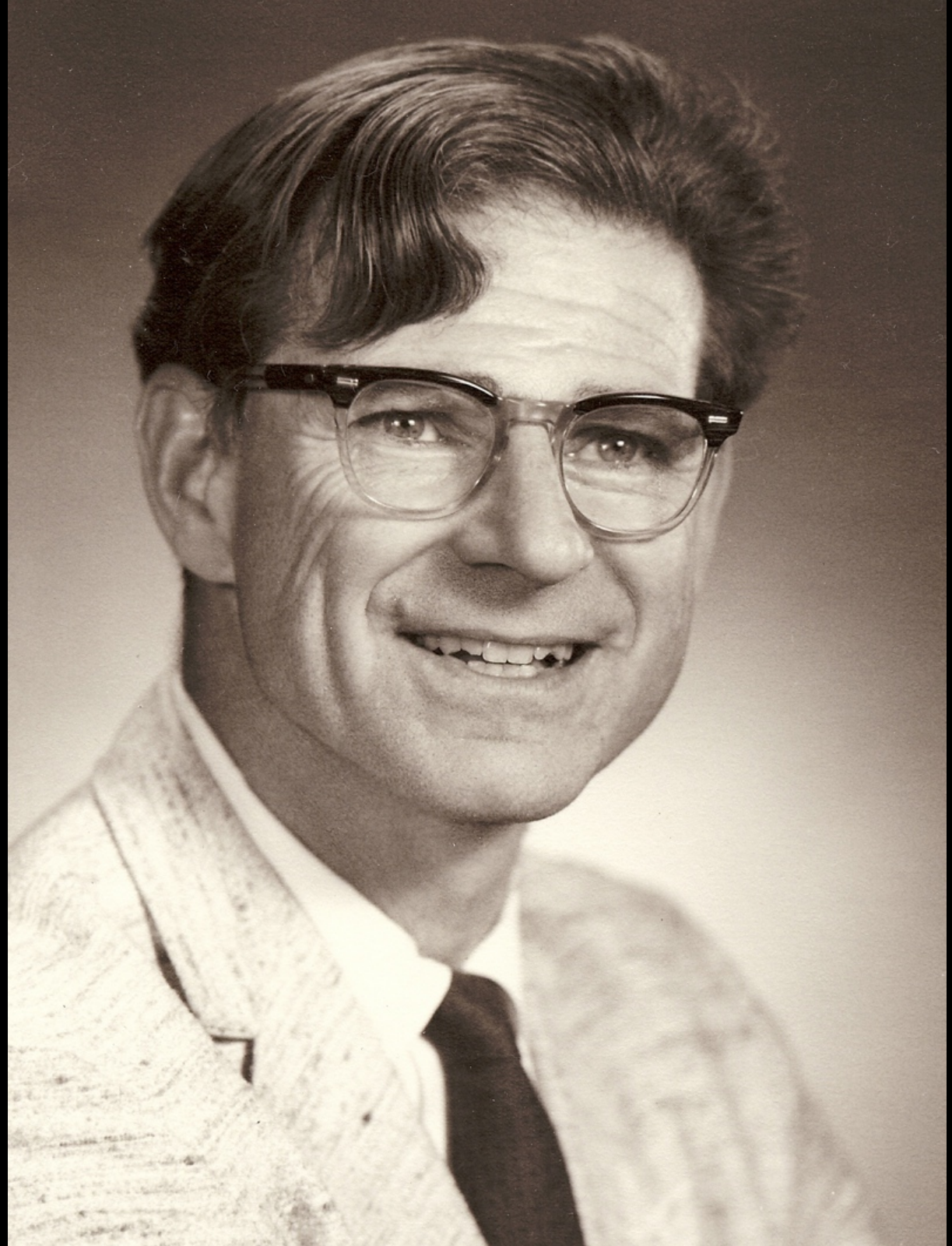
Fig. 10. Same as in Fig. 9 for NGC 6231, $m - M = 12.50$, $E(B-V) = 0.46$, log $age = 6.75$

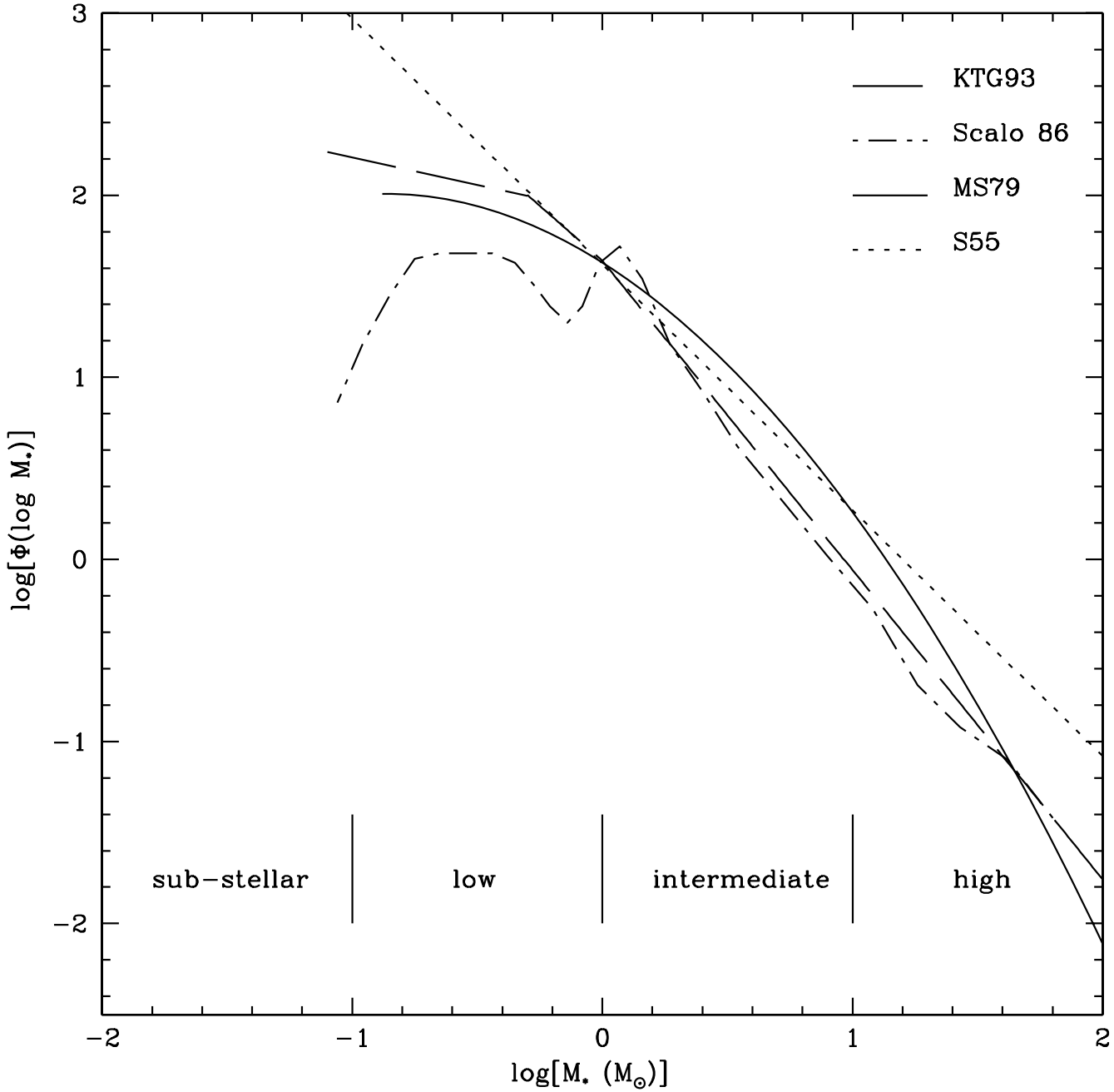
Meynet et al. 1998

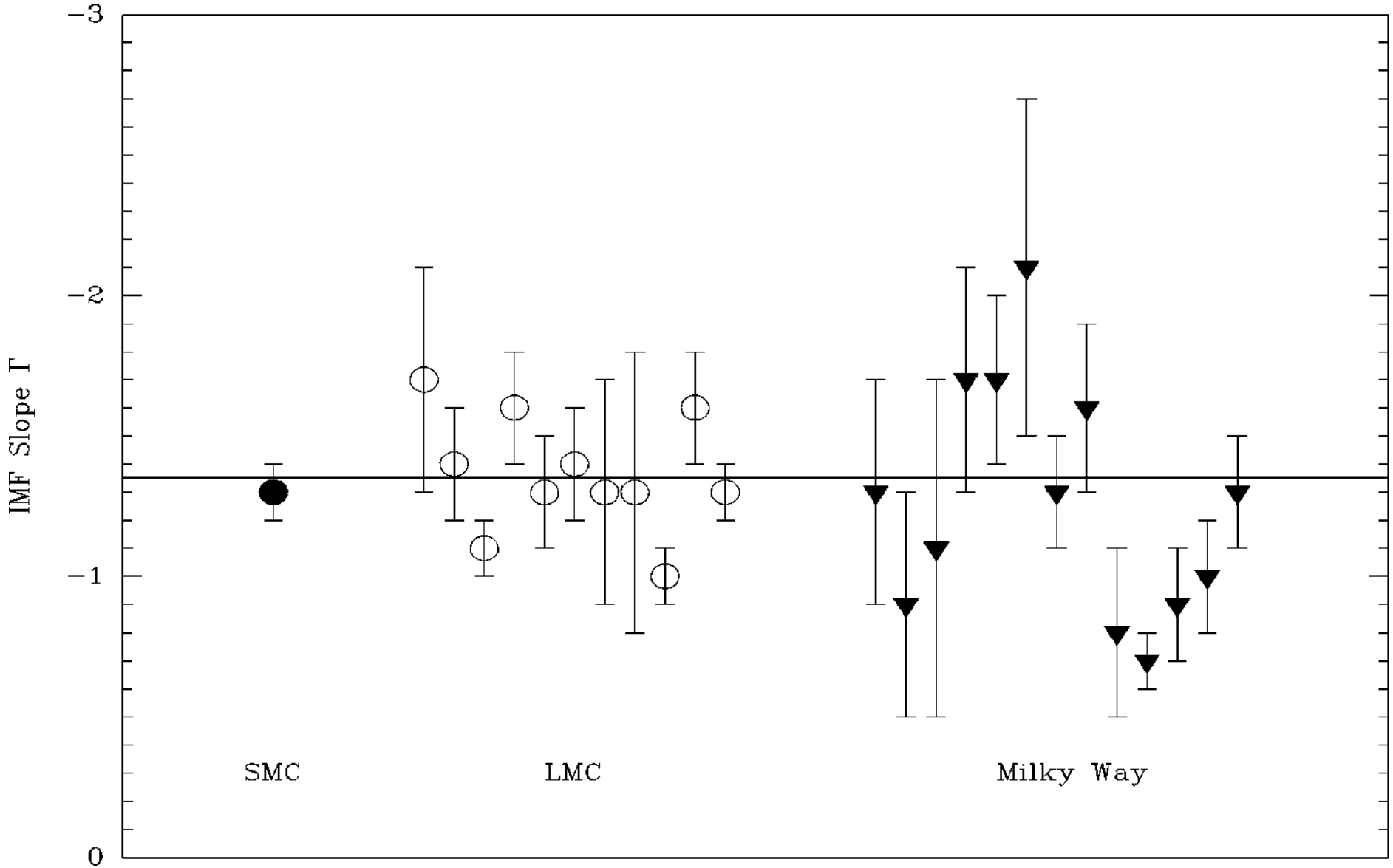

Ultraviolet
Visible
Infrared
n = ∞
n = 4
n = 3
n = 2
n = 1
13.6 eV
12.8 eV
12.1 eV
10.2 eV
0 eV
Absorption
Emission
Ionization
Paschen series
Balmer series
Lyman series
Ground state


©Mark Hanson, Data , Martin Pugh - El Sauce, Chile

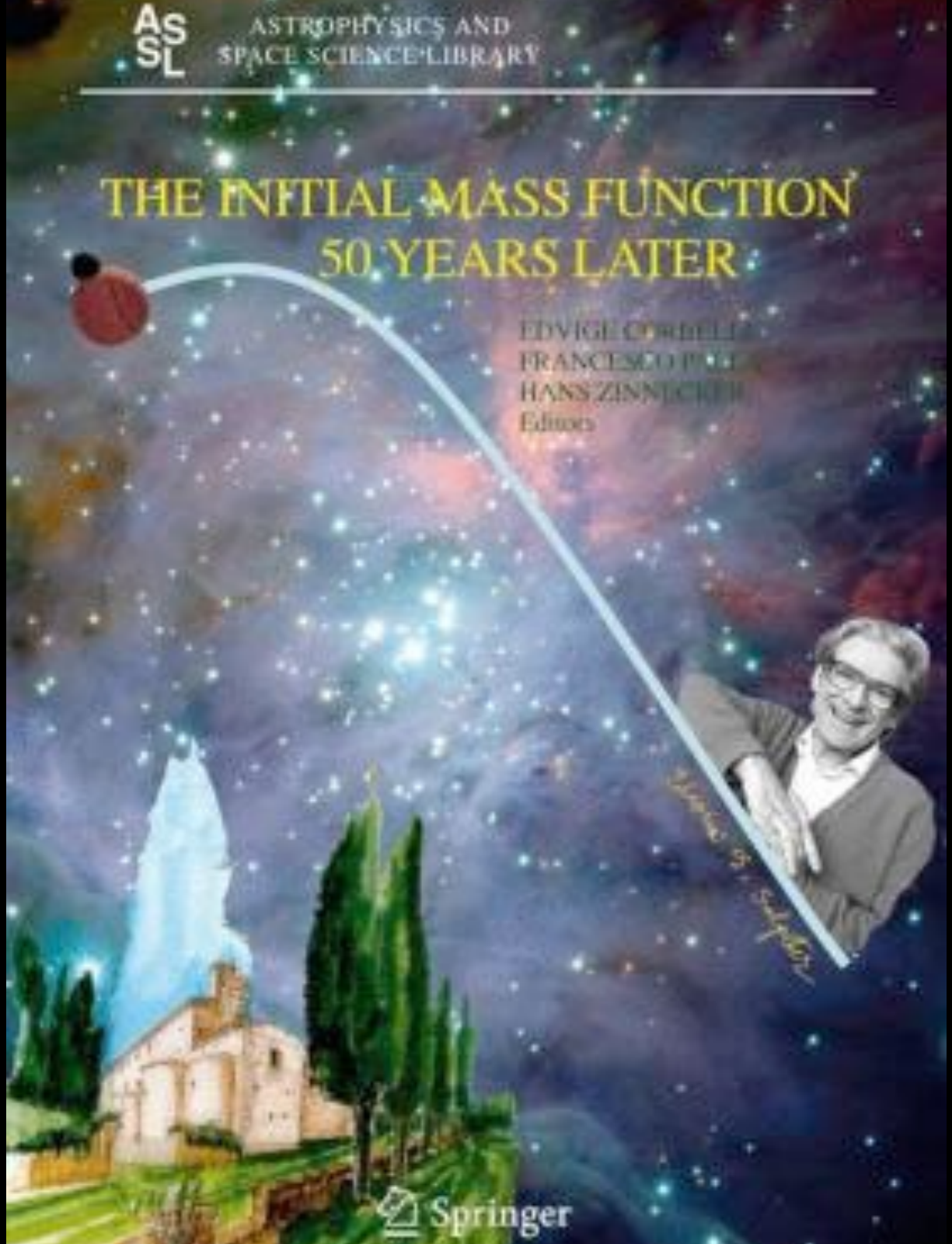

Sextans B
Sextans A
1 million ly
Leo A
NGC
3109
Antlia
Dwarf
180°
Leo I
Leo II
Canes
Dwarf
NGC
185
NGC
147
M110
270°
IC10
90°
Milky
Way
Andromeda
Galaxy
NGC
6822
M32
0°
Triangulum
Andromeda
II, III and I
Phoenix
Dwarf
IC
1613
Pegasus
Dwarf
Tucana
Dwarf
Cetus
Dwarf
LGS 3
Aquarius
Dwarf
WLM
SagDIG




KTG93
Scalo 86
MS79
S55
sub−stellar
low
intermediate
high
log[Φ(log M.)]
log[M. (M⊙)]
3
2
1
0
−1
−2
−2
−1
0
1
2



Massey 2003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