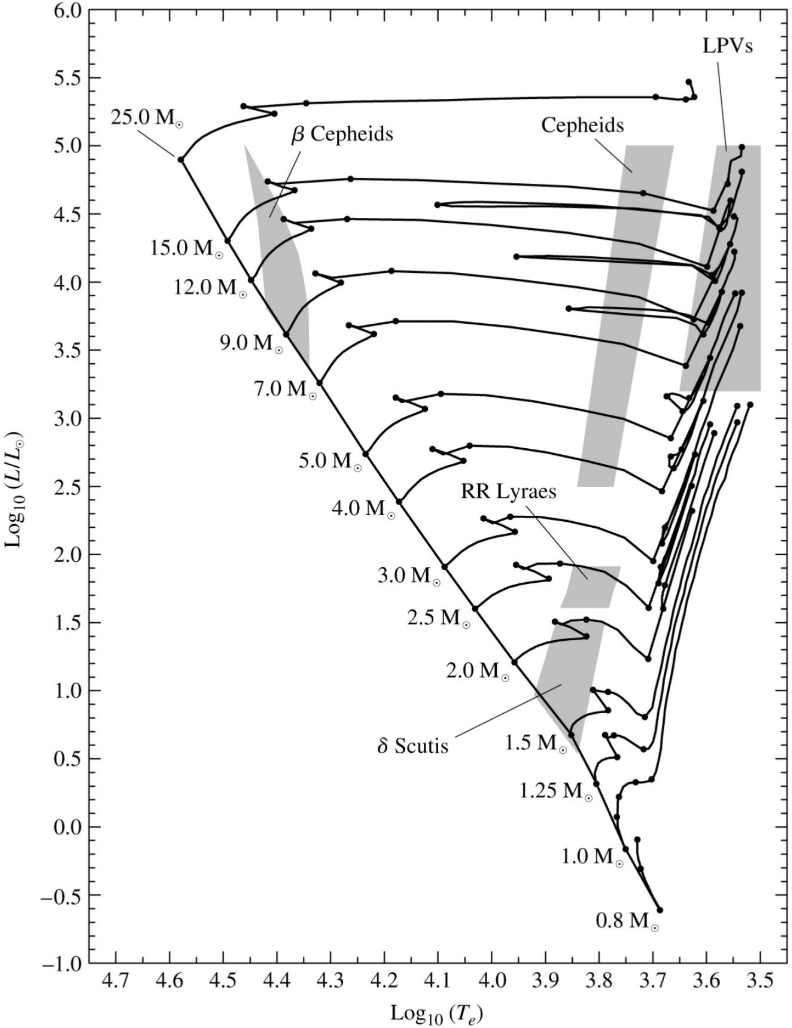
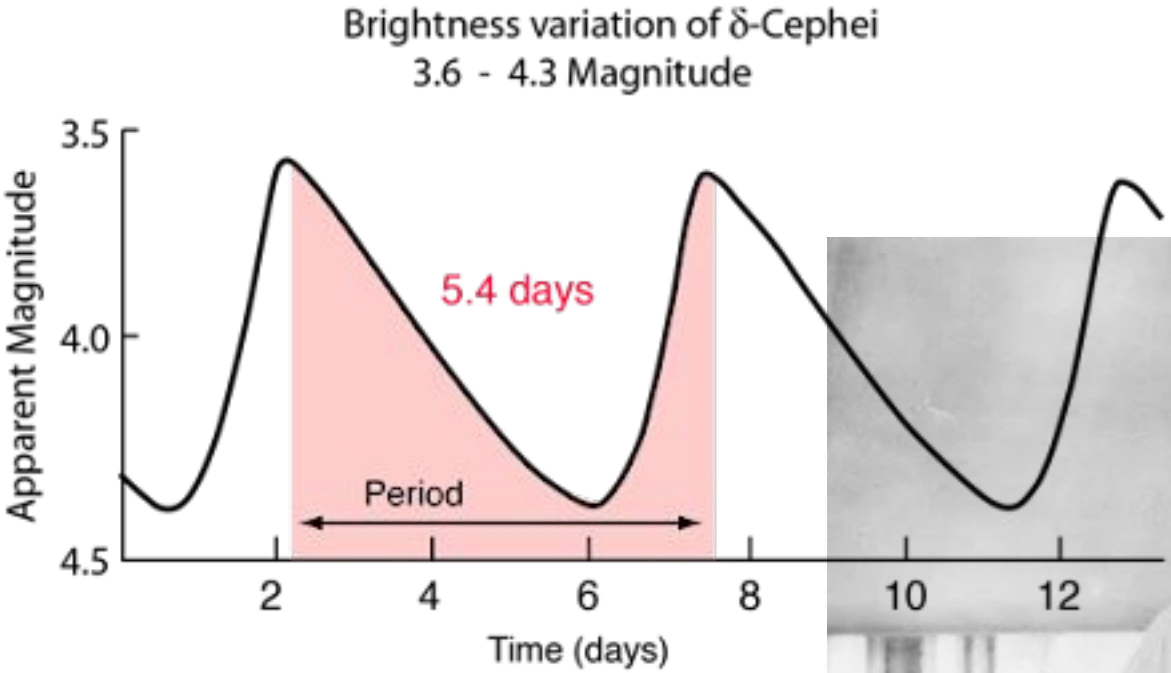
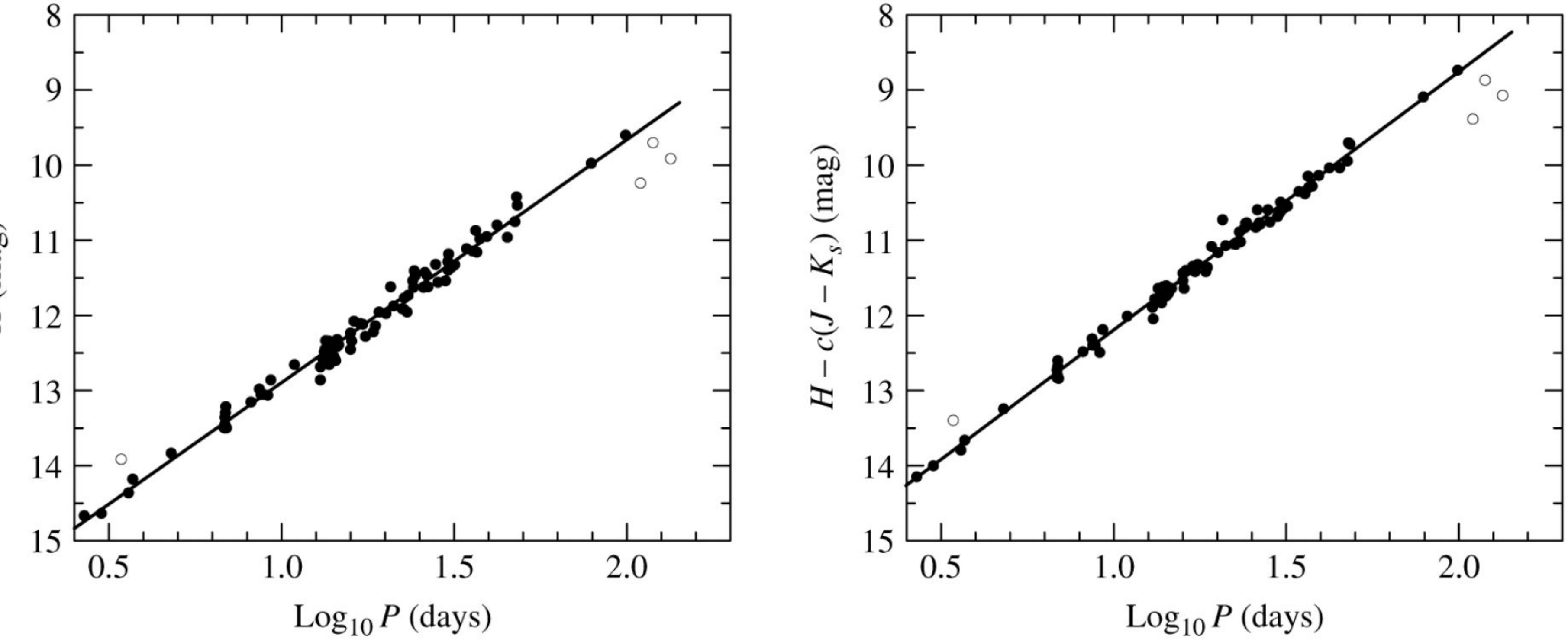
ASTR702

Stellar Pulsations

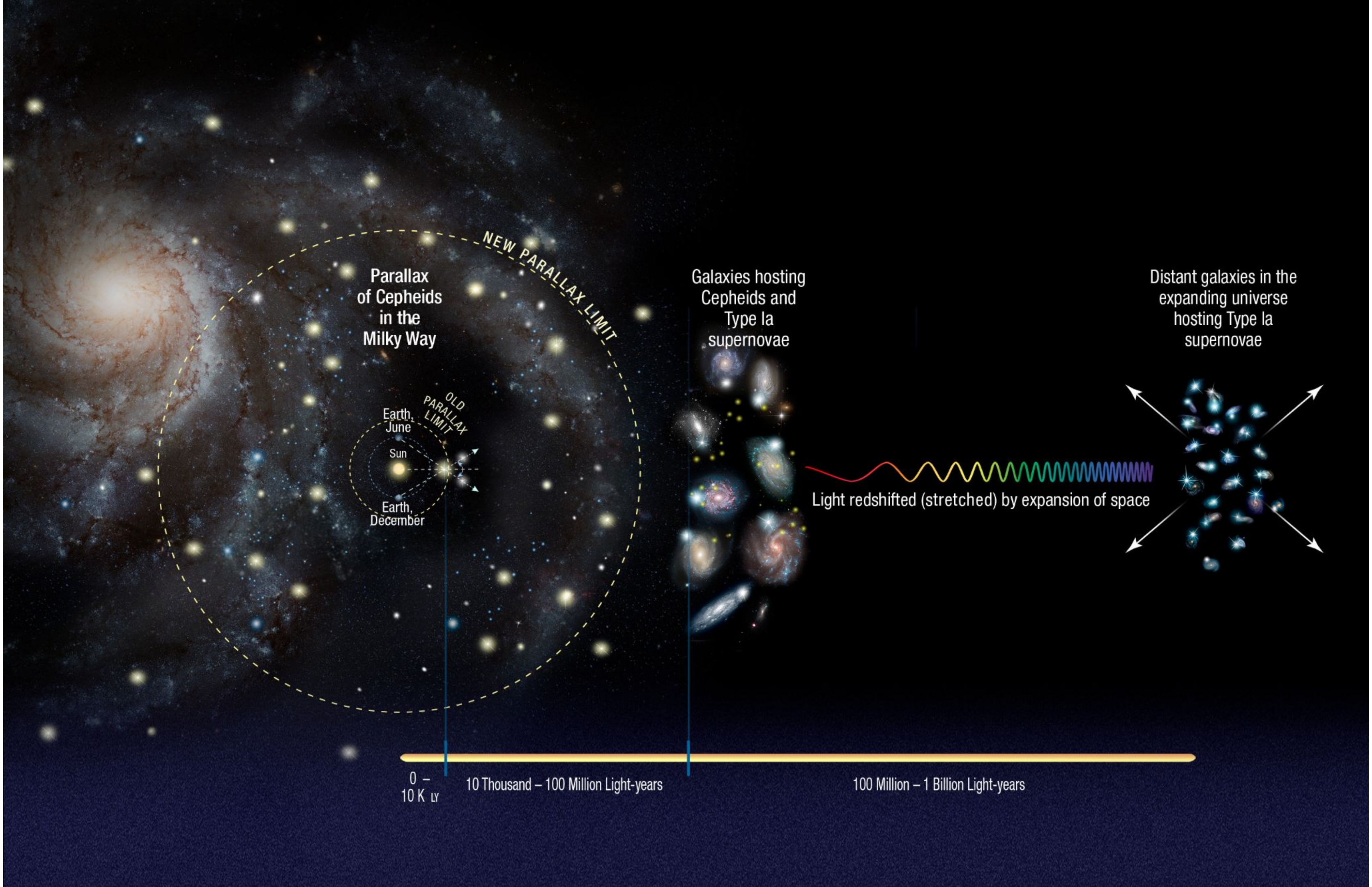


LPVs
Cepheids
β Cepheids
25.0 M☉
15.0 M☉
12.0 M☉
9.0 M☉
7.0 M☉
5.0 M☉
4.0 M☉
3.0 M☉
2.5 M☉
2.0 M☉
1.5 M☉
1.25 M☉
1.0 M☉
0.8 M☉
RR Lyraes
δ Scutis
Log10 (L/L☉)
Log10 (Te)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4.0
3.9
3.8
3.7
3.6
3.5


Brightness variation of δ-Cephei
3.6 - 4.3 Magnitude
Apparent Magnitude
3.5
4.0
4.5
5.4 days
Period
2
4
6
8
10
12
Time (days)



8
9
10
11
12
13
14
15
0.5
1.0
1.5
2.0
Log10 P (days)
8
9
10
11
12
13
14
15
H − c(J − Ks) (mag)
0.5
1.0
1.5
2.0
Log10 P (days)



Parallax of Cepheids in the Milky Way
NEW PARALLAX LIMIT
OLD PARALLAX LIMIT
Earth, June
Sun
Earth, December
Galaxies hosting Cepheids and Type Ia supernovae
Light redshifted (stretched) by expansion of space
Distant galaxies in the expanding universe hosting Type Ia supernovae
0 – 10 K LY
10 Thousand – 100 Million Light-years
100 Million – 1 Billion Light-years

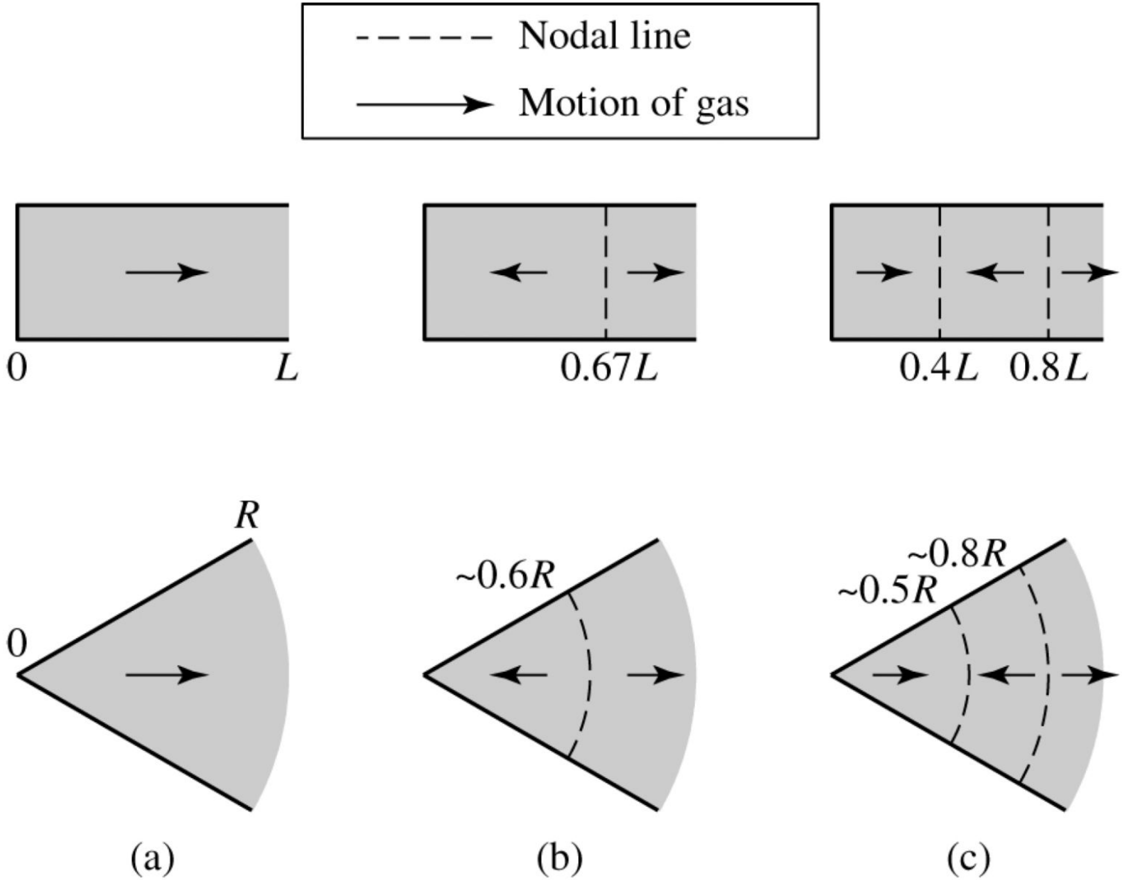
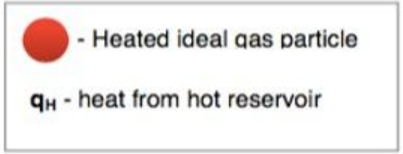
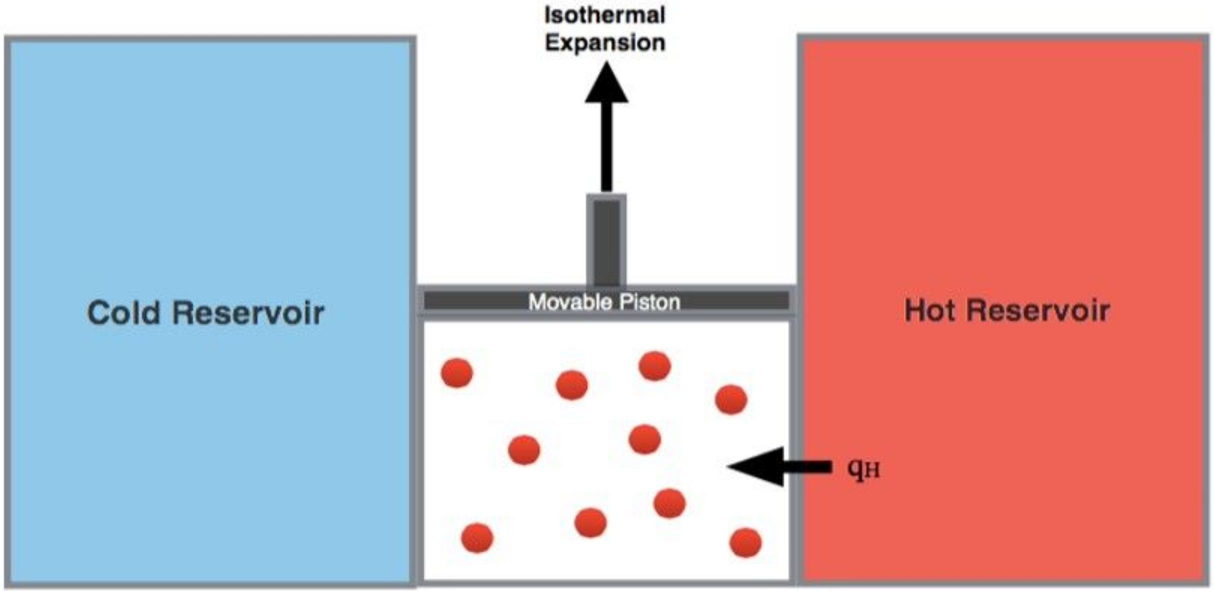


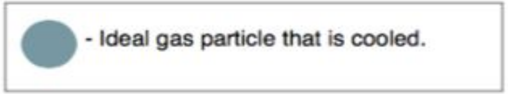
Figure 3: Radial pulsation modes for (L to R) fundamental, first overtone, and second overtones.

Stage One:



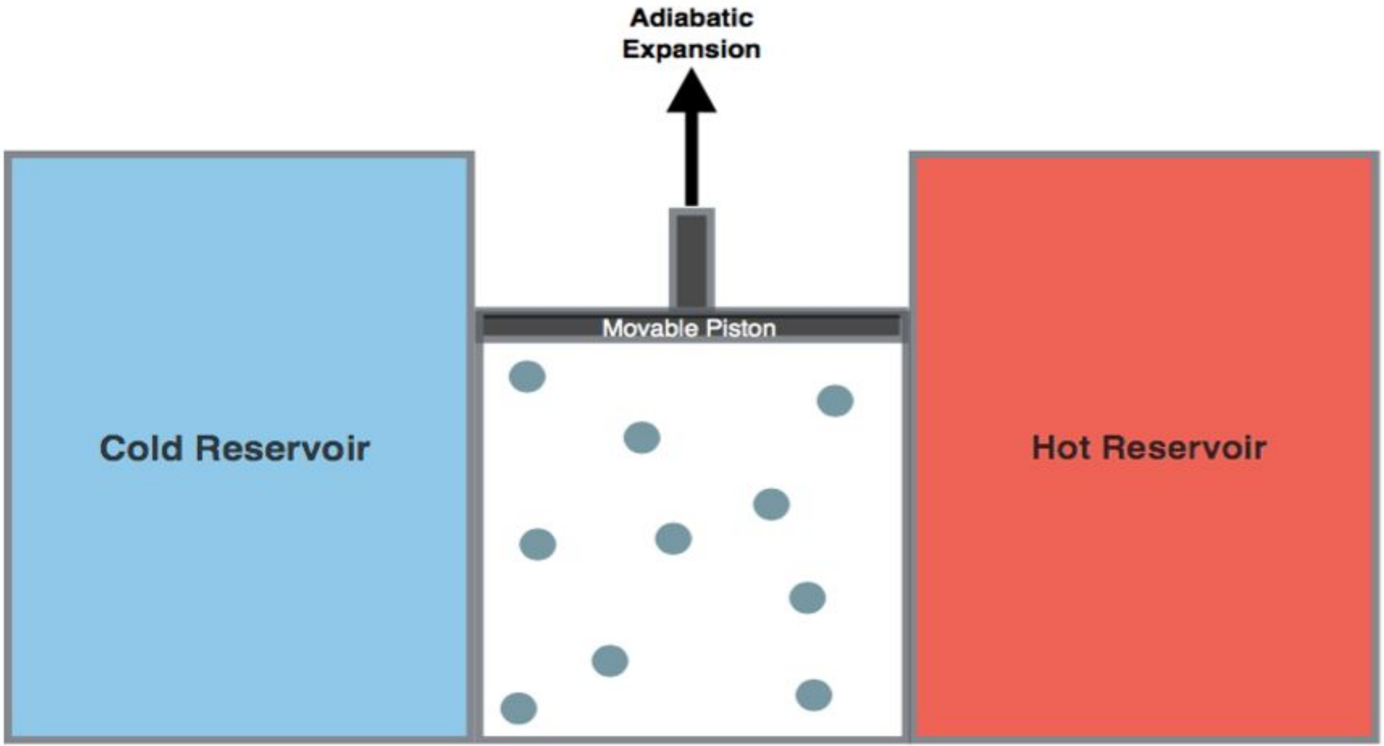
At this stage heat is released from the hot reservoir and is absorbed by the ideal gas particles within the system. Thus, the temperature of the system rises. The high temperature causes the gas particles to expand; pushing the piston upwards and doing work on the surroundings.





Stage Two:

At this stage expansion continues, however there is no heat exchange between system and surroundings. Thus, the system is undergoing adiabatic expansion. The expansion allows the ideal gas particles to cool, decreasing the temperature of the system.

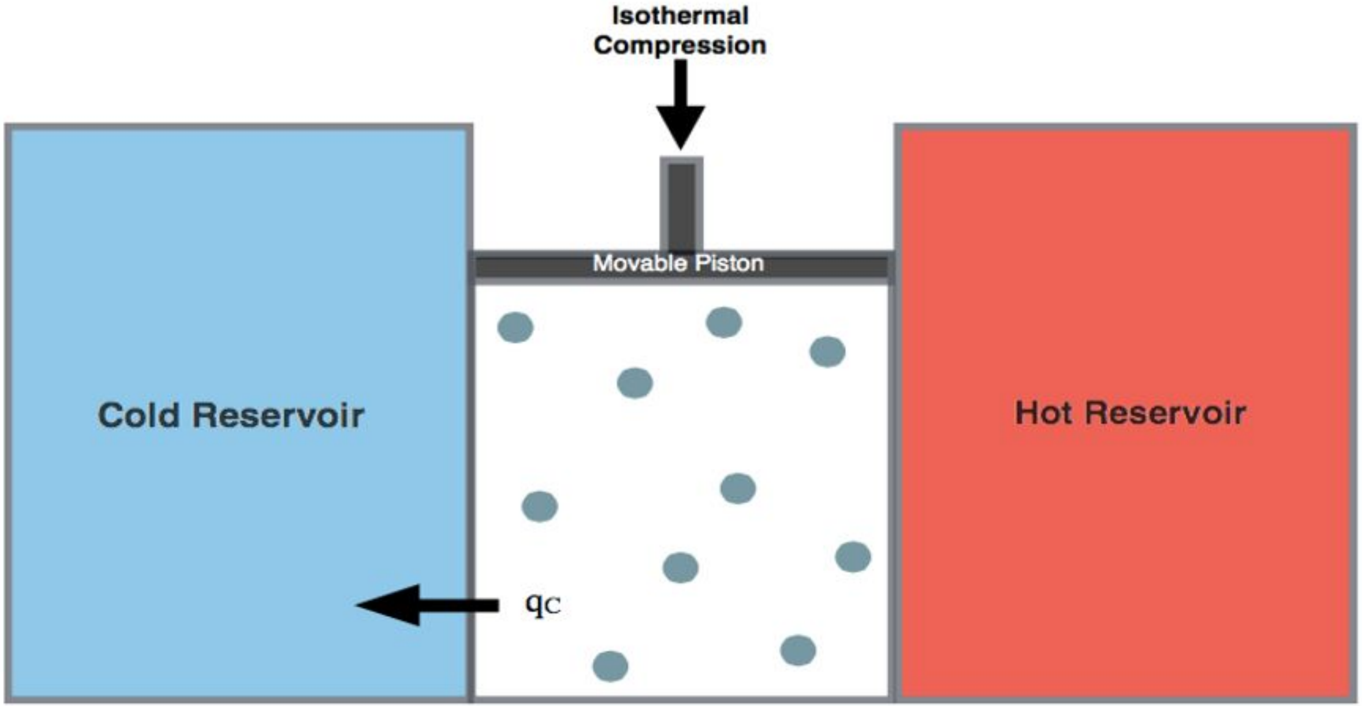


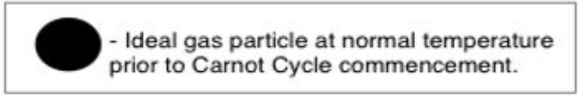
Stage Three:

q_C - heat released from system to cold reservoir

- Ideal gas particle that is cooled.

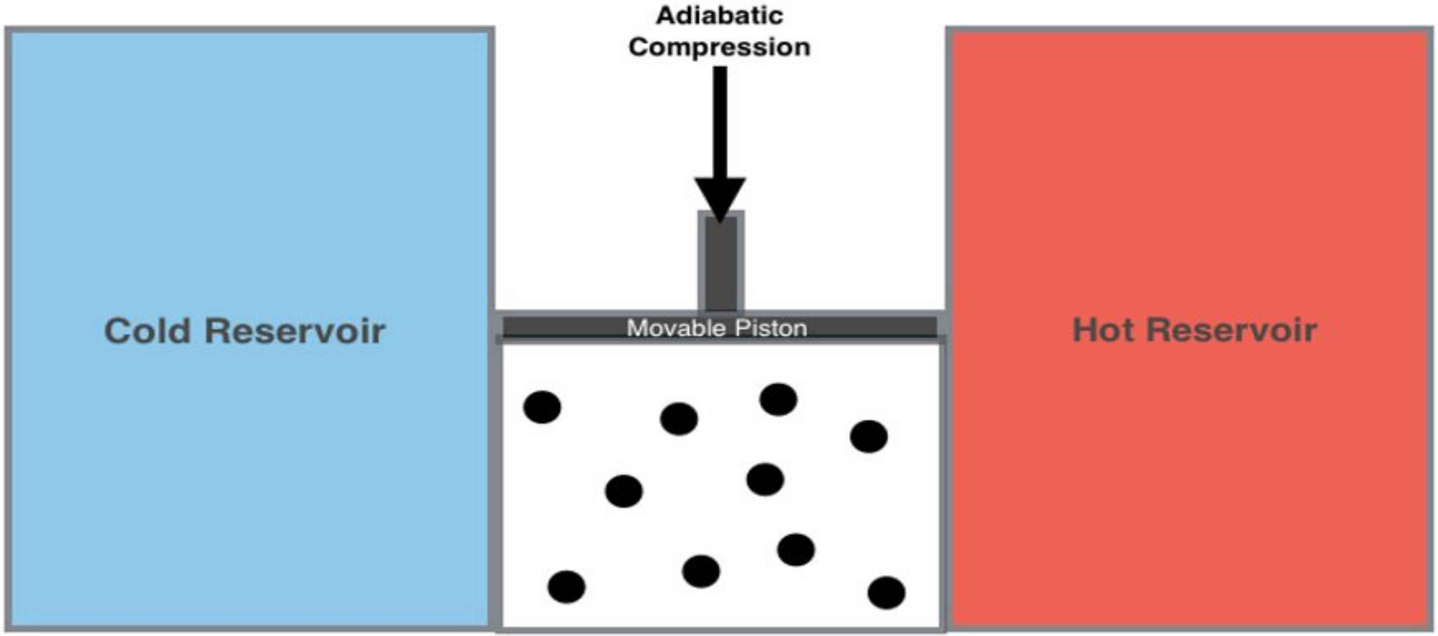
At this stage the surroundings do work on the system which causes heat to be released (q_C). The temperature within the system remains the same. Thus, isothermal compression occurs.

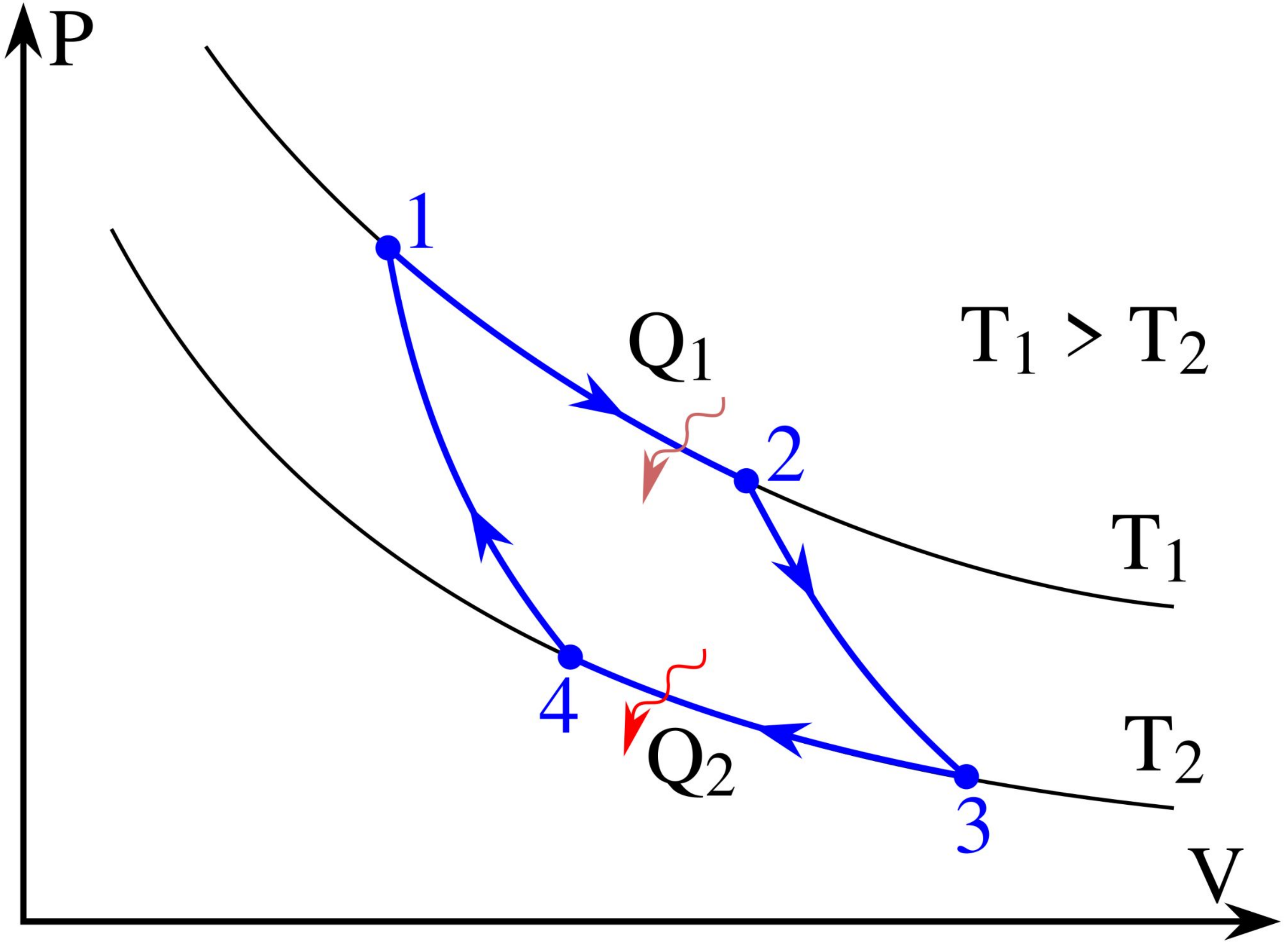




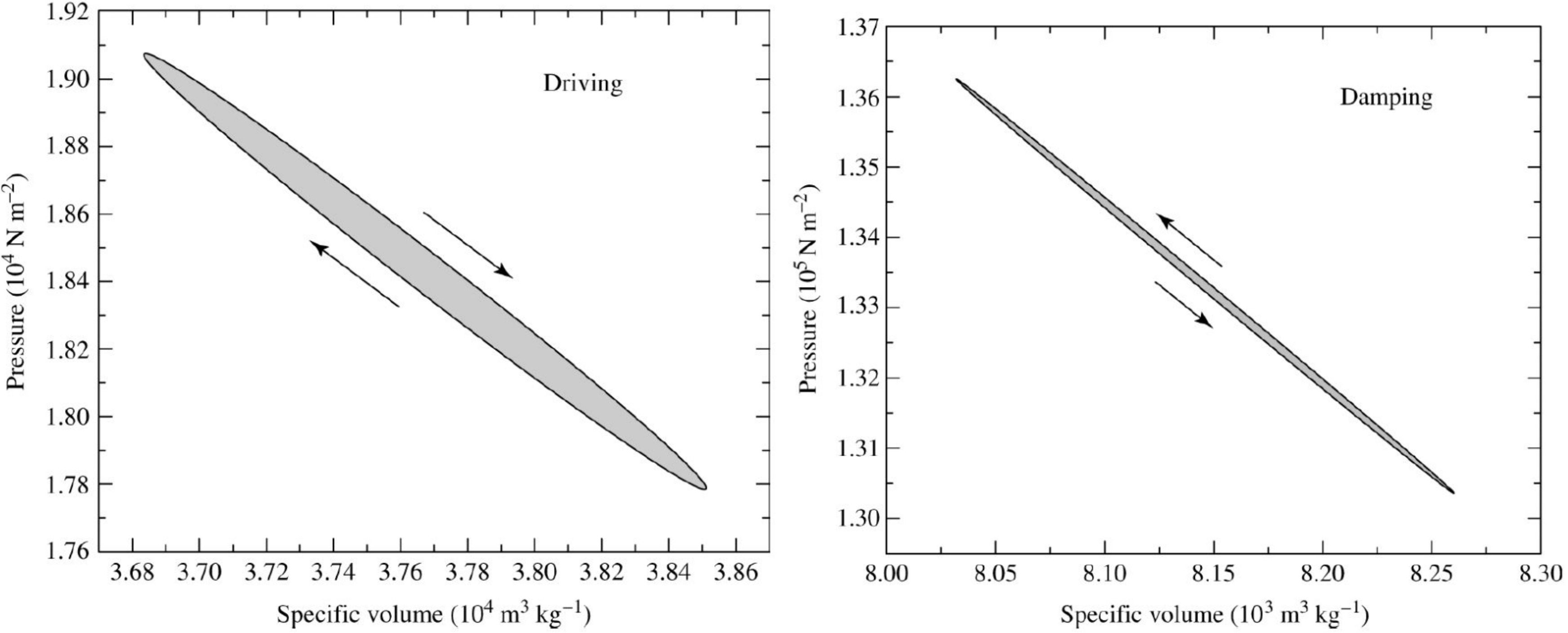
Stage Four:

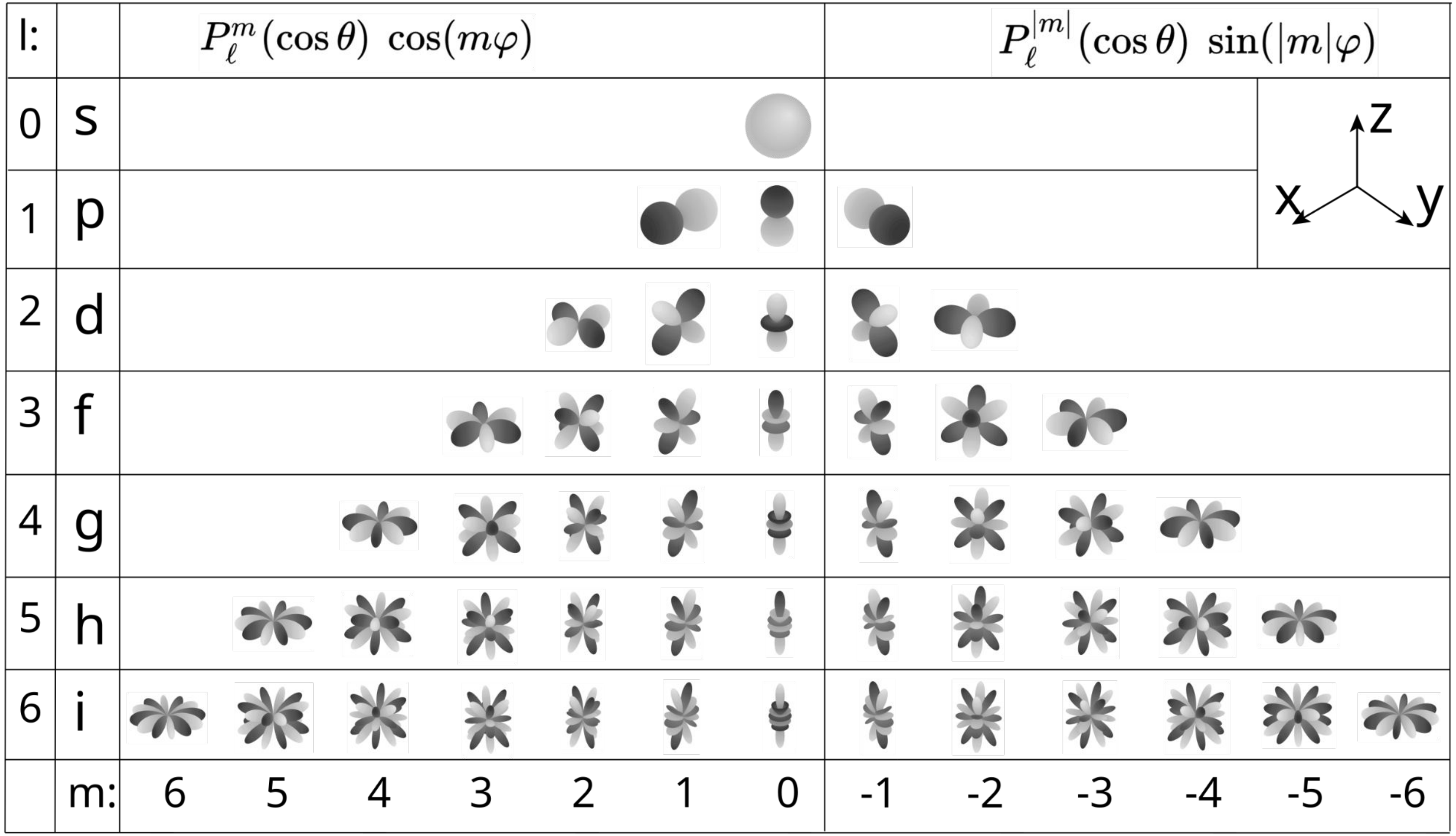
No heat exchange occurs at this stage, however, the surroundings continue to do work on the system. Adiabatic compression occurs which raises the temperature of the system as well as the location of the piston back to its original state (prior to stage one).





P
V
1
2
3
4
Q1
Q2
T1 > T2
T1
T2


Driving
Pressure (10^4 N m^{-2})
1.92
1.90
1.88
1.86
1.84
1.82
1.80
1.78
1.76
3.68 3.70 3.72 3.74 3.76 3.78 3.80 3.82 3.84 3.86
Specific volume (10^4 m^3 kg^{-1})
Damping
Pressure (10^5 N m^{-2})
1.37
1.36
1.35
1.34
1.33
1.32
1.31
1.30
8.00 8.05 8.10 8.15 8.20 8.25 8.30
Specific volume (10^3 m^3 kg^{-1})


l:
$P_\ell^m(\cos\theta)\ \cos(m\varphi)$
$P_\ell^{|m|}(\cos\theta)\ \sin(|m|\varphi)$
0 s
1 p
2 d
3 f
4 g
5 h
6 i
z
x
y
m: 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6

https://upload.wikimedia.org/wikipedia/commons/1/12/Rotating_spherical_harmonics.gif