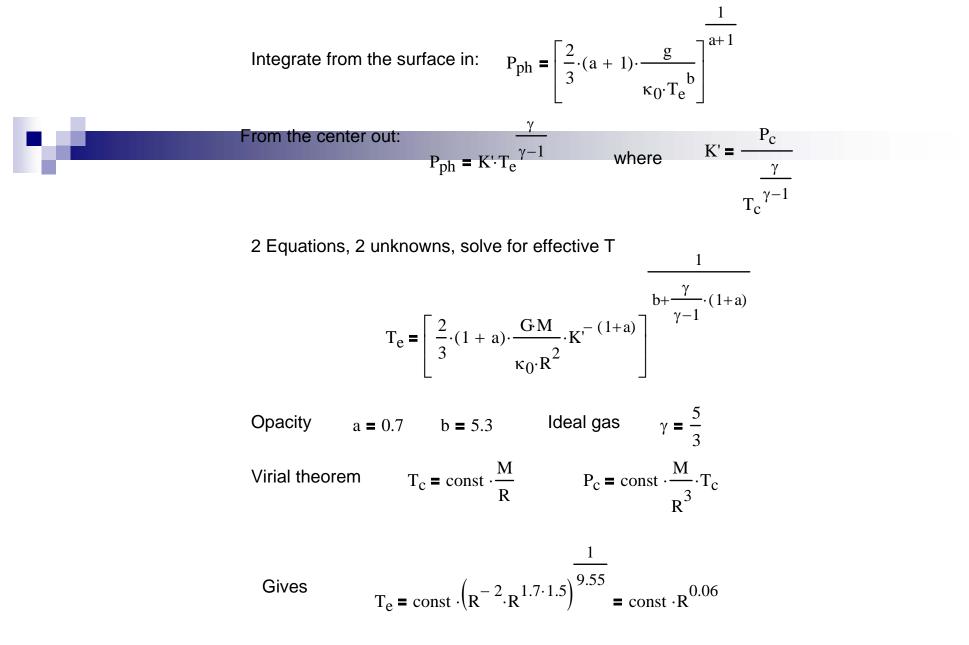
Handout 20: Evolution and Nature of stars

To recap

□ Low T stars are fully convective

- High Kramers' opacity in the interior
- High heat capacity just below the photosphere
 H and He ionization
- Luminosity determined by matching convective interior to radiative photosphere
 - See next slide, 2 equations, 2 unknowns, solve for effective T ~ R^{0.06}.

□ Nearly vertical track (Hayashi) on the H-R diagram



i.e. nearly vertical tracks on H-R diagram

Stars start large, therefore cool, therefore convective

- Star contracts
 - □ Half the P.E. used to heat the interior
 - Half released as luminosity
 - Kelvin-Helmholtz timescale
- Thigh enough to develop radiative core
 - Luminosity determined by opacity
 - \Box L ~ M³/ κ
 - \Box For f-f + f-b (Kramers) $\kappa \sim \rho T^{-3.5}$
 - \Box L ~ R^{-0.5}
 - L and effective T increase as star contracts

Radiative track, nearly horizontal

Track moves to left and up on H-R diagram

- Contraction continues till nuclear energy generated in the center exactly equals luminosity emitted from the surface ("Thermal equilibrium")
 - Nuclear time scale ~ 10 Gy for sun
- More massive stars heat up enough to be dominated by e-scattering opacity throughout the interior
 - L independent of radius
 - □ Tracks exactly horizontal on H-R diagram
 - Till "Thermal Equilibrium"

Less massive stars stay convective

For M < 0.4 solar</p>

- □ T never high enough to become radiative
- □ Track stays vertical right down to M.S.
 - Nuclear energy = Luminosity
- M.S. lifetime ~ $M/L \sim M^{-2 \text{ to } -3}$
- For M < 0.1 solar Brown dwarf
 - Electron degeneracy pressure stops contraction
 - About 1 Jupiter radius
 - Central temperature never reaches 3 million K
 - □ H-burning not possible
 - □ Cools eternally