What is Energy Source of Sun?

E = m c^2

Conservation of mass and energy

Nuclear reactions

Gravitational Energy

Primary Source of Energy is

Thermonuclear Fusion

Conversion of Hydrogen to Helium

Need High Temperature, High Pressure

Structure of Sun

Sun is a Gas

Sun is in Pressure and Thermal Equilibrium

Energy Radiated at Surface is Balanced by Energy Generated in Interior

Temperature is Highest in Center 15 Million Deg

Nuclear Reactions Occur in Center

Heat Flows from Center to Surface

Model of Sun

Nuclear thermostat

Russell Vogt Theorem

Explanation of Main Sequence Provides Way to Understand Red Giants, White Dwarfs

Importance of Composition

Effect of Converting Hydrogen to Helium in Central Regions

Tests of Solar Model

Neutrino Observatories

Neutrino Problem

Fewer Observed than Predicted. Problem now understood

Solar Pulsations as Probes of Structure

Proton-proton, CNO cycles

Sun's Life About 10 Billion Years

Massive Stars - Few Million Years

Evolution to Red Giants

Conversion of H to He in core

Note Lifetimes for Different Masses

Note Paths on H-R Diagram

Color-Magnitude Diagrams of Clusters

Age-Dating of Clusters

Composition Effects

Tests of Stellar Evolution

Evolution after red giant stage

Dense helium core

Degenerate matter

Core becomes very hot, shrinks

Helium flash, conversion to carbon

Horizontal branch stars

Mass Loss

Planetary Nebula

Evolution to white dwarf stage

White dwarfs, very dense, approx. size of earth.

Chandrasekhar limit - above 1.4 solar masses, white dwarf collapses

Evolution of Sirius and its white dwarf companion

Variable Stars

Pulsating Variables

Cepheids, RR Lyrae Stars

Expand and Contract

Period-Luminosity Relation

Help establish distance scale of universe

Help test stellar models

Location of instability strip in H-R Diagram

Massive stars evolve differently

No helium flash, elements produced up to iron in core

Core collapse, supernova

Violent explosion of entire star

SN1054 produced Crab Nebula

Types I and II

SN1987A - detection of neutrinos, test of models

SN enrich ISM in heavy elements

SN can produce neutron stars

Neutron stars – 10 km radius

Density of atomic nucleus