Background/previous work

Rotation is common in stars. Indeed, the currently accepted idea for the evolution of protostellar disks relies strongly on a rotating disk and protostar, with angular momentum transfer between the two. The effects of rotation, however, have not been studied as rigorously, particularly in the area of stellar populations. In a theoretical rotating reference frame, the gravitational force (directed radially inward) is partly offset by a centrifugal force resulting from the rotation, particularly around equatorial latitudes, where the physical velocity of matter is greatest.

Thermohaline mixing, or thermohaline convection, occurs in the post-main-sequence stage of stellar evolution. It represents a hydrodynamic instability that arises when the differential of mean molecular mass with respect to radius/mass inside the star is positive, i.e. molecules are, on average, more massive closer to the surface. If the differential is non-positive, there is no such instability under stellar conditions (locally, the density and temperature gradients are assumed to be stable and the region is convective). This mixing is treated as a diffusive process, as transport of species occurs along a concentration gradient, in the manner of regular diffusion. The conditions for thermohaline mixing are not attainable under the assumptions made for isolated, main-sequence stars, which produce a negative molecular-mass gradient as heavier nuclei fall inwards on average and core nuclei fuse together. However, binaries (via accretion) and RGB stars (via dredge-up) can undergo significant fast mixing such that the gradient is inverted and thermohaline mixing occurs.

Radiative levitation

In stellar interiors, there is a radiative flux of photons generated by core fusion reactions. These photons do not escape from the star directly, as they often interact with the opaque matter in the stellar interior, transferring linear momentum to ions.

Research area/key questions

Rotation

Rotation effects produce significant variations in the properties of a star as viewed by an distant observer. These include lower luminosities and effective temperatures due to reduced gravitational pressure (and hence temperature) in the core, which slows down the fusion reaction rate. This allows for an extended main sequence lifetime for star of a given mass. The key question is to quantify any extension and to visualise any potential knock-on effects in the post-MS stages of the stellar lifetime. Radiative levitation, which is modelled as a radially-outwards effect, also reduces the effective (inwards) gravity.

Thermohaline mixing allows for more material from the central regions to reach regions near the surface in a given time by moving along a concentration gradient, which changes the apparent surface photometry

Radiative levitation

Clusters?

Given theoretical time constraints on the star-formation stages of star clusters, which are relatively isolated.

Contribution of the research to the field

The research, by incoporating the effects of thermohaline mixing, rotation and radiative levitation directly into each step of the description of stellar evolution, will allow for more realistic appraisal of observation data. By producing isochrones for more complex theoretical stars, some of the apparently strange occurences in the CMDs of stellar populations can be explained from first principles.

The potential for the research is greatest when considering the cumulative effect of these individual processes. Estimates of rotation have already been used in conjuction with observed populations, but the mixing effects currentyl have practical limits, mostly concerning the computational rescources required for repeated calculations across many different species.

Proposed methodology

1. Thermohaline

2. rotation

3. levitation

References