A MASSIF Effort To Determine The Mass-Luminosity Relation For Stars of Various Ages, Metallicities, and Evolution States

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The MASSIF (Masses and Stellar Systems with Interferometry) Team will use SIM to investigate the mass content of the Galaxy — from huge stars to barely glimmering brown dwarfs, and from hot white dwarfs to exotic black holes. We will target various samples of the Galactic population to determine and relate the fundamental characteristics of mass, luminosity, age, composition, and multiplicity — attributes that together yield an extensive understanding of the stars. Our samples will include distant clusters that span a factor of 5000 in age, and commonplace stars and substellar objects that lurk near the Sun.

Mass is the most fundamental characteristic of a star. It governs a star's entire evolution — determining which fuels it will burn, what color it will be, and how long it will live. It is crucial to our understanding of stellar astrophysics that we determine stellar masses to high accuracy. Knowing the masses of main sequence stars answers basic stellar astrophysics questions such as, *What is the biggest star? How is the mass of a stellar nursery partitioned into various types of stars?* and, *What is the mass content of the Galaxy and how does it evolve?* In fact, the dependence of luminosity upon mass — the mass-luminosity relation (MLR) — is one of the few stellar relations sufficiently fundamental to be applicable to many areas of astronomy. With the exception of the H-R Diagram, it is the single most important "map" of stellar astronomy.

The principal goals of the MASSIF Key Project are to (1) define the mass-luminosity relation for main sequence stars in five fundamental clusters so that effects of age and metallicity can be mapped (Trapezium, TW Hydrae, Pleiades, Hyades, and M67), and (2) determine accurate masses for representative examples of nearly every type of star, stellar descendant, or brown dwarf in the Galaxy. To reach these goals we will measure masses with errors of 1% or less for roughly 200 stars, which will allow us to challenge stellar astrophysics models more severely than ever before. There are currently only ~40 stars with masses this accurately known, and 30 of those are components in eclipsing binaries with masses between 1 and 3 $M_{\odot}$. Thus, the range of our understanding of precise stellar masses is terribly limited. SIM can rectify this situation because it has the capability to measure precisely the largest known mass for a star, as well as the smallest known mass for a brown dwarf. The extrema of the H-R Diagram will receive intense scrutiny so that we can understand just where the stellar main sequence begins and ends. We will also investigate exotic targets such as supergiants and black holes to further our understanding of these rare but intriguing objects. In the process of carrying out this investigation, we will develop a well-stocked "toolbox" of mass-luminosity relations at optical and infrared wavelengths that can become the standards against which all stars are measured.

An important consequence of our program will be accurate masses for stars that have extrasolar planets. SIM will not "see" planets — it will only measure the effects that planets have on their host stars. Even when combined with high-precision radial velocity data, an estimate of the star's mass is required to derive the mass of the planet. Our ensemble of mass-luminosity relations will allow accurate estimates for the masses of stars with extrasolar planets, and consequently, accurate estimates for the planet masses.

In addition, because the proposed observations will target 100 or more relatively close binary systems (separated by tens of AU or less), a search for planets in those systems will be carried out. Currently, we have no understanding of planetary survival in stellar binaries that have separations similar to our solar system. Thus, through the MASSIF effort, perhaps we can finally answer the question, *Is it possible to have two nearby Suns hanging in the sky of a world?*

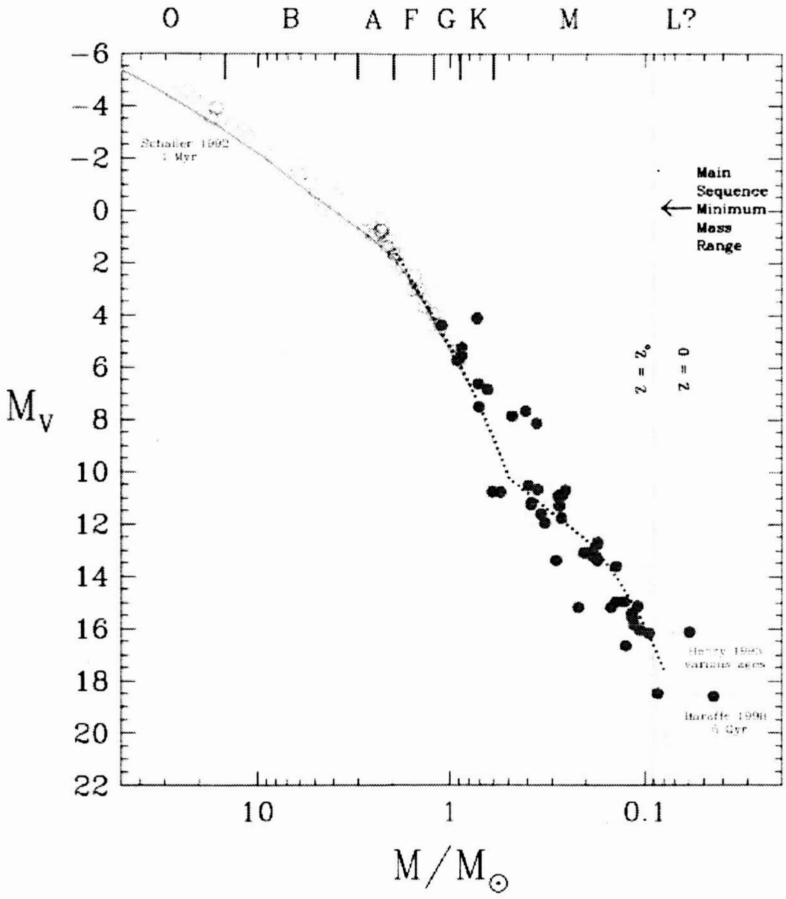

Figure 1: The Mass-Luminosity Relation at optical wavelengths for field stars is shown. Masses from 30 $M_\odot$ to 0.08 $M_\odot$ are represented by open points for eclipsing binaries and solid points for astrometric binaries. The region from 0.092 and 0.072 $M_\odot$ marks the minimum main sequence mass range for objects with zero to solar metallicity. Three fits are shown — model fits for massive stars from Schaller *et al* (1992) and for low mass stars from Baraffe *et al* (1998), and empirical fits (dotted line) from Henry & McCarthy (1993) and Henry *et al* (1999). Each fit has a terminus near 1 $M_\odot$.