Stellar Ages of the *DEBRIS* Sample Stars

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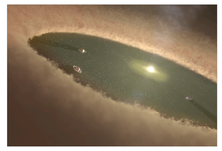

Abstract

The European Space Agency Herschel mission will launch later this year. DEBRIS, or Disc Emission via a Bias- Reconnaissance in the Infrared/Sub-millimetre, was selected as a Key Project. The DEBRIS project will represent the most sensitive search toward main sequence stars for debris disks undertaken to date. The flux limited survey will be an unbiased search for dusty disk systems toward 450 nearby dwarf systems ranging in spectral class from A through M stars. The stars are drawn from the population of nearby main sequence stars. To get ready for the Herschel mission, the DEBRIS team has done a detailed literature search for information on the sample objects. One of the key components is the stellar age. Our survey, when complete, will allow us assess how the disk properties might evolve with spectra type as a function of stellar age. Here we present an overview of the DEBRIS program along with a preliminary discussion of the range of ages found to date among our sample stars.

1. Introduction

DEBRIS disks can be characterized as flattened distributions of dust and larger bodies located at radii between 10 and 1000 AU around main-sequence stars. The lifetime for dust in orbit is much shorter than the estimated age of the host star. Instead, the dust is believed to be replenished from collisions of larger comets and asteroids that orbit the host star, hence the "debris". Originally 4 stars were discovered by IRAS in 1983. Since, then they have been very actively studied in the IR and submm wavelengths where most of their thermal emission can be detected (see for example [5]. Still, after 25 years of research, only about 20 debris disks have been resolved (see www.disksite.com). These limitations have restricted our ability to test models of how such disks might evolve with time. Since the debris disks are provide a link to how planetesimals might or might not assemble during the formation of planetary systems, it is critical to get better overall statistics on debris disks properties.

IN 2009, the European Space Agency will launch the Herschel satellite, detected to high resolution, high sensitivity infrared observations. Among the key programs selected by ESA was *D*EBRIS - or Disc Emission via a Bias Reconnaissance in the Infrared/Sub-millimetre. The project, lead by PI Brenda Matthews, is to search for debris disks around a large sample of main sequence stars ranging across spectral types from A0 through late M.

The program will address many issues, including:

- In an unbiased sample, how many main sequence stars have debris disks?
- What are the properties of the debris disk population?
- What portion of the debris disks can be spatially resolved?

2. The Source Sample

NEARBY stars offer the best chance for an unbiased survey that would permit detailed followups including the ability to probe any spatial structure that might exist. For this reason, the DEBRiS team decided that a flux limited survey at 100 and 160 microns offers the best opportunities to find spatially resolved disks in a variety of spectral types between A0 and late M.

DEBRIS target stars include some 450 systems that are evenly distributed across spectrall types A through M. The sources include the nearest examples of stars of each spectral type that cover a range of metallicities, stellar ages, and binarities (with 20 arcseconds). DUNES (DUst around NEarby Stars) is another debris disk program on Herschel. We have divided so that both teams can achieve their goals as efficiently as possible on as many sources as possible. The result is that the DEBRIS team will lead the observations on some 348 primaries, and have data for a total of 446 nearby primaries in the final sample which consist of:

- 89 M stars
- 92 K stars
- 89 G stars
- 93 F stars
- 83 A stars

3. Age Estimate Techniques

ONE of the key criteria for any models will the the stellar age. For this reason, we have conductedr a search for any age estimates that might exist for our stars.

OUR sample stars are all nearby, so that unlike cluster studies, we have to find individual ages for the stars. As part of that effort, we have gone searched the literature for any age estimates of our sample primary stars. As might be guessed, some spectral classes are better represented than others in the literature. The techniques used for stars in our sample include:

Activity-Rotation Diagnostics This method is a "tweak" of previous models to try and produce updated age estimates. [3]

Chromospheric Age The use of tracer elements such as Li and Ca combined with chromospheric activity to date a star's age. [12], [1]

Common Stellar Group If a group of stars formed together, then stars that are part of the group can be dated by using the determined ages of other group members. [4], [2]

Gyrochronology Uses the relationship between the *v sin i* of a star and its age. [1]

Isochrone Age Uses various factors to place a star on an isochrone. [11], [7], [9], [6], [8], [10]

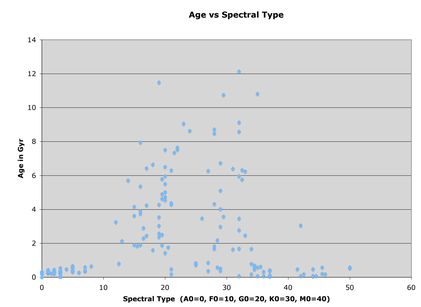

Figure 1: *Age in Gigayears vs the Primary Star's Spectral Class. Going from A0 to M9. Typical age uncertainties are 15-20%*

4. Results So Far

A Review of the literature finds 158 out of 446 stars (35%) have at least some age estimate. Current ages are most abundant for the well studied A and G stars (over 40% and 60% respectively). However, a lot of work has happened in the last few years to improve data on nearby stars in the F and K spectral classes (now about 30% have ages).

FOR the bulk of the M stars (almost 90%), no age has yet been assigned. In part this is due to the fact that many of the M stars have only recently been identified. In addition, the M stars have little age direct age data - and so most of the age data comes from the identification of many of the stars as being part of a moving stream. Without that, hardly any of the M stars would have a known age. In addition, since the known M stars are part of a relatively young stream of stars, we might expect that ages for other M stars will cover a greater range than currently we see.

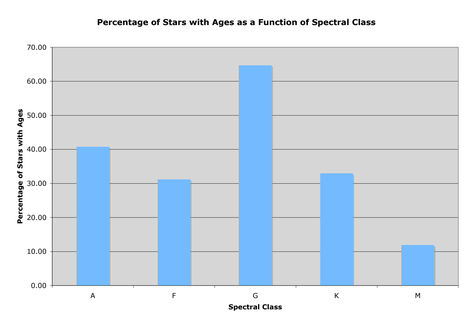

Figure 2: *Percentage of Stars with Ages as a function of Spectral Type.*

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