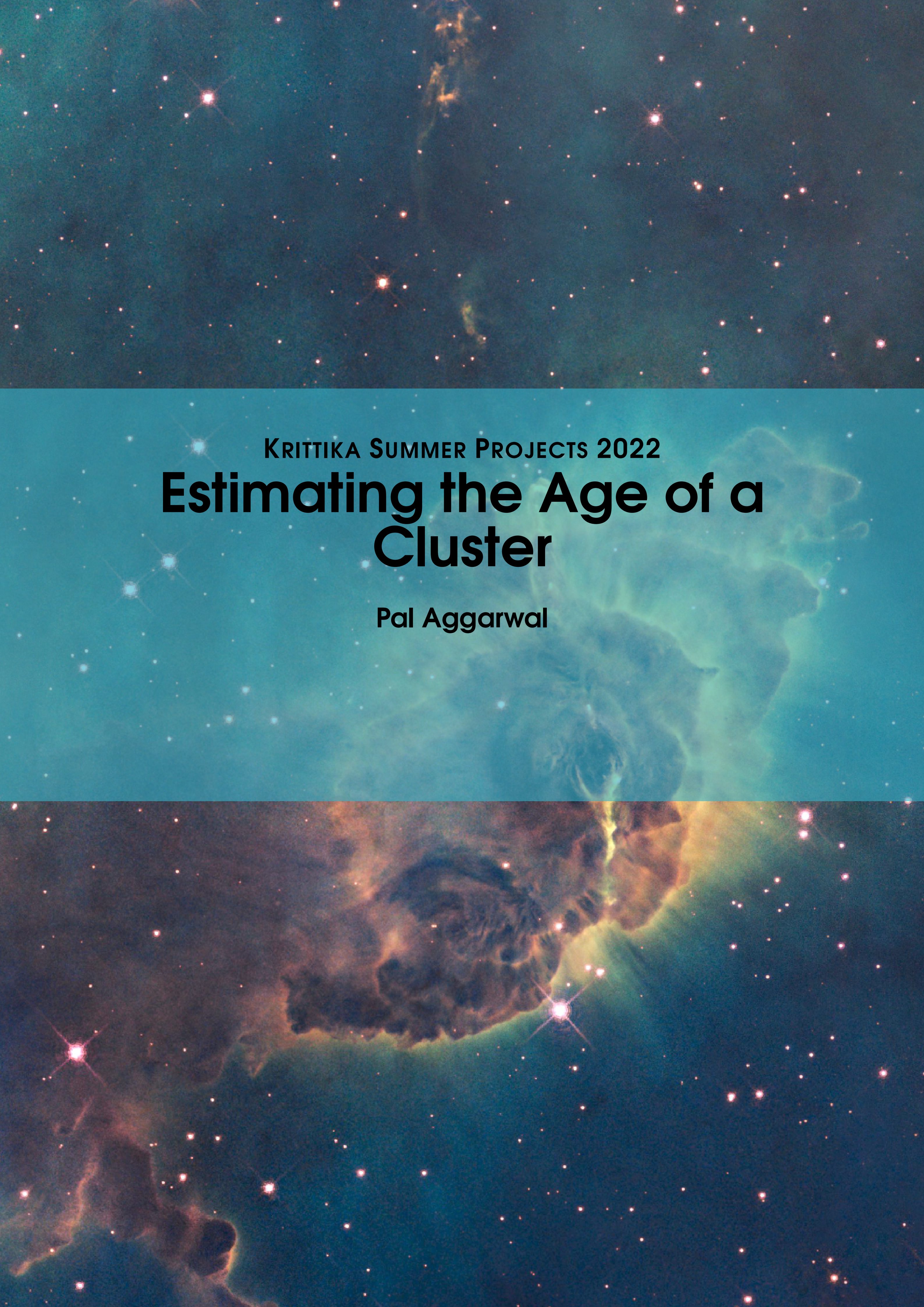

KRITTIKA SUMMER PROJECTS 2022

# Estimating the Age of a Cluster

Pal Aggarwal

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# Estimating the Age of a Cluster

**Pal Aggarwal**[1]

[1]Indian Institute of Technology, Bombay, 400076, India


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# Contents

# Part One - Theory

# 1. Star Clusters

## 1.1 Introduction

A star cluster is a group of stars that share a common origin and are gravitationally bound for some length of time. They are are particularly useful to astronomers as they provide a way to study and model stellar evolution and ages.

## 1.2 Types of Star Clusters

The two basic categories of stellar clusters are open clusters, also known as galactic clusters, and globular clusters.

- **Open Clusters**
  Open clusters are so-named due to the fact that the individual component stars are easily resolved through a telescope. Some examples such as the Hyades and Pleiades are so close that the individual stars can be clearly distinguished by the naked eye. They are sometimes called galactic clusters due to their location on the dusty spiral arms on the plane of spiral galaxies. Stars in an open cluster have a common origin - they formed from the same initial giant molecular cloud. Clusters typically contain a few hundred stars though this can vary from as low as a few dozen up to a few thousand.
- **Globular Clulsters**
  Globular clusters contain several thousand to one million stars in spherical, gravitationally-bound system. Located mostly in the halo surrounding the galactic plane they comprise the oldest stars in the galaxy. These Population II stars are highly evolved but with low metallicities. Clusters are so old that any star higher than a G or F-class will have already evolved off the main sequence. There is little free dust or gas found in globular clusters so no new star formation is taking place in them. Stellar densities within the inner regions of a globular cluster are very high compared with regions such as those around the Sun.

## 1.3 Cluster Ages

Star clusters are particularly important because they allow astronomers to check models of stellar evolution and the ages of stars. Let us look firstly at open clusters to understand why this is so.

Stars in an open cluster have a common origin from a given nebula. They therefore share the same initial metallicity so any effect of this on stellar evolution is effectively the same for the members of the cluster. Another important point is that all stars within a cluster are effectively at the same distance form an observer on Earth. Even though a cluster may be a few parsecs across this size is insignificant compared with the much greater distance of the cluster from Earth. If we take photometric readings for the cluster stars, the apparent magnitude of each thus also allows us to infer the relative absolute luminosities of the cluster members. The stars that appear brightest within a cluster are intrinsically more luminous than fainter members.

Astronomers use this fact to obtain a colour-magnitude diagram for a cluster. This is simply an HR diagram that plots apparent magnitude, usually V (or mV) on the vertical axis against colour index, B - V on the horizontal.

# 2. Some Concepts

Let's first understand some useful terminology relevant to the project.

## 2.1 Hertzsprung-Russell Diagram

The Hertzsprung–Russell diagram, abbreviated as H–R diagram, HR diagram or HRD, is a scatter plot of stars showing the relationship between the stars' absolute magnitudes or luminosities versus their stellar classifications or effective temperatures. The diagram was created independently in 1911 by Ejnar Hertzsprung and by Henry Norris Russell in 1913, and represented a major step towards an understanding of stellar evolution.

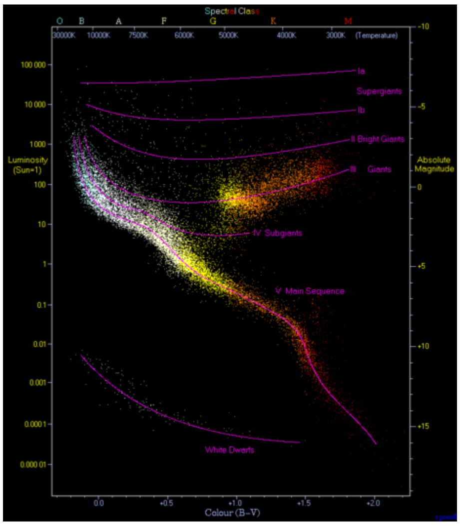


Figure 2.1: HR Diagram

## 2.2 Photometry

Photometry, from Greek photo- ("light") and -metry ("measure"), is a technique used in astronomy that is concerned with measuring the flux or intensity of light radiated by astronomical objects.(1) This light is measured through a telescope using a photometer, often made using electronic devices such as a CCD photometer or a photoelectric photometer that converts light into an electric current by the photoelectric effect. When calibrated against standard stars (or other light sources) of known intensity and colour, photometers can measure the brightness or apparent magnitude of celestial objects.

For the project, we have used images of **M53 (NGC 5024) Globular Cluster** from PanSTARRS in different bands and performed PSF Photometry on them.

While doing photometry on crowded star fields, such as globular clusters or open clusters, aperture photometry will not yield reliable results. It is better to use a Point Spread Function: a gaussian that can be fitted to all of the stars in the field in order to find their magnitudes.

# II

# Part Two - Results and Inference

# 3. Presenting Information

## 3.1 HR Diagrams

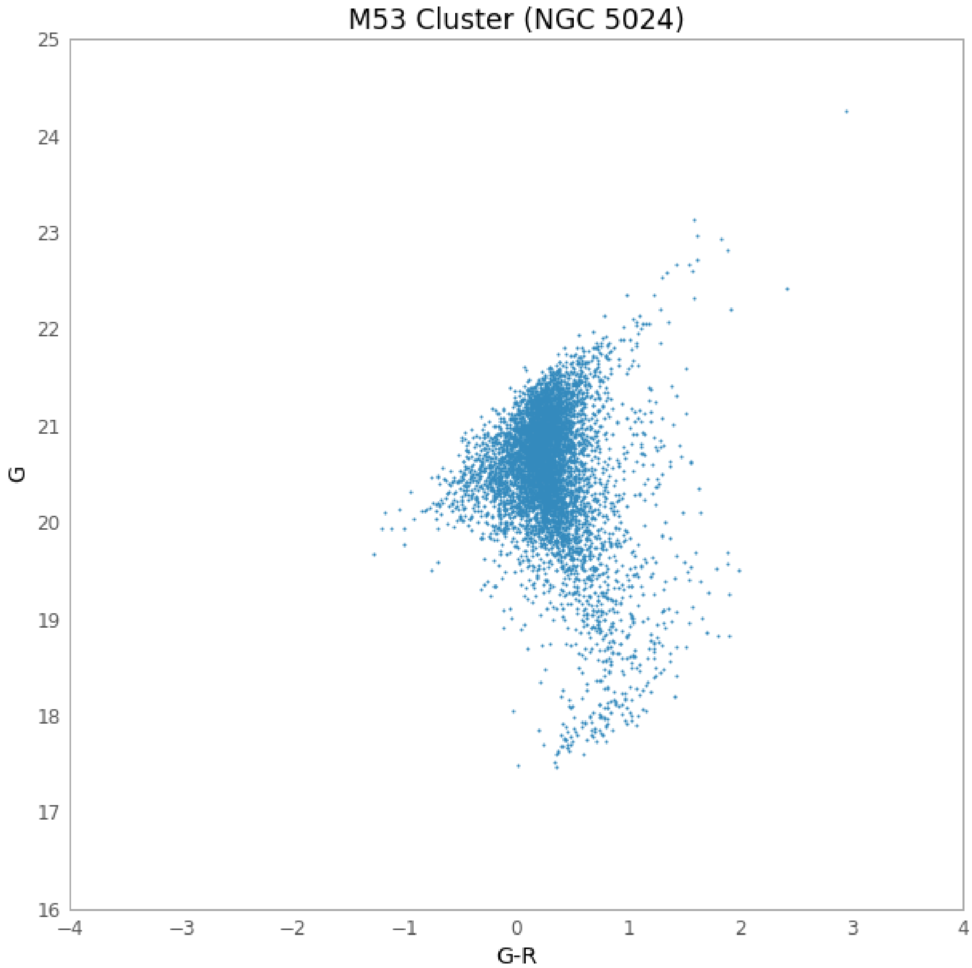


Figure 3.1: G vs G-R HR Diagram for M53

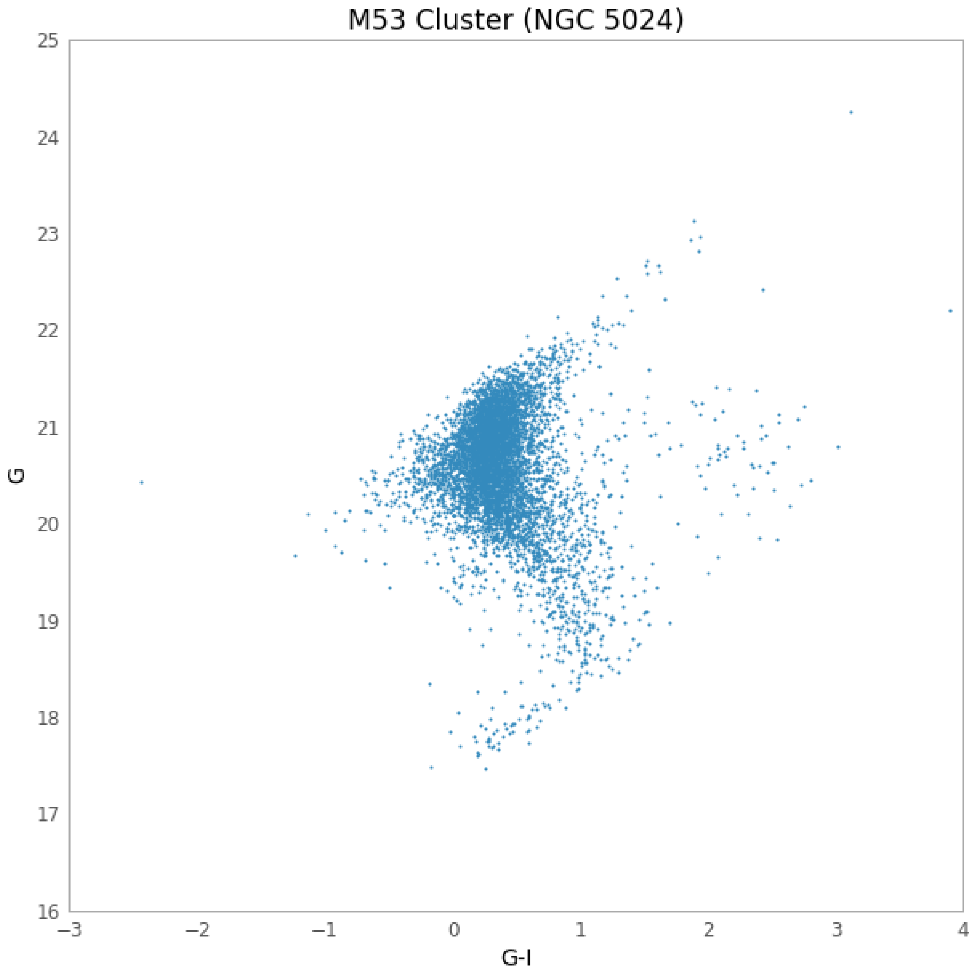


Figure 3.2: G vs G-I HR Diagram for M53

## 3.2 Isochrone Fitting

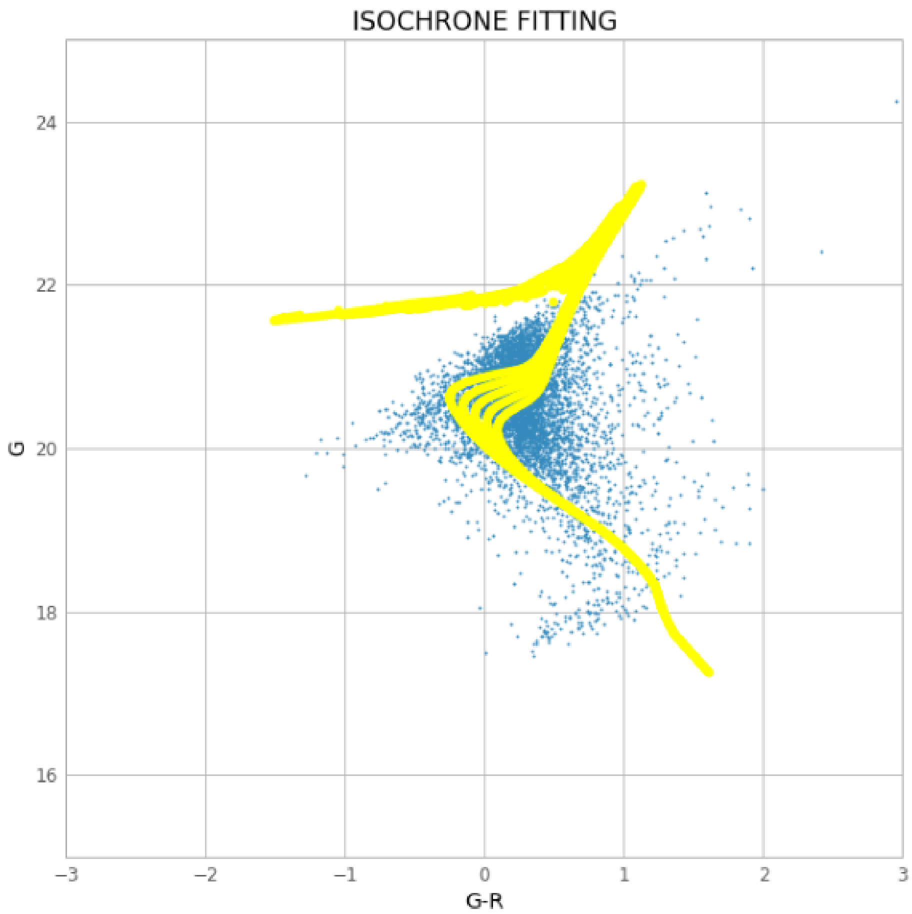


Figure 3.3: Isochrone Curve Fit for M53

## 3.3 Inference

We see that the isochrone corresponding to log10(age)=10.1 fits the HR diagram best. This means that the age of M53 is $10^{10.1}$ **= 12.589 Gyr** which is very close to the experimentally determined age of the cluster, i.e., 12.6 Gyr.

## 3.4 References


- What are Star Clusters?
- Types of Star Clusters
- What is HR Diagram?
- What is Photometry?