20250520 Stellar Mass Map on Voronoi Binning

1. Load data

I have two files. One is the voronoi binng map:

```
Filename: IC3392_SPATIAL_BINNING_maps.fits
No.    Name        Ver    Type       Cards   Dimensions    Format
  0  PRIMARY         1 PrimaryHDU        4   ()
  1  BINID           1 ImageHDU         26   (437, 438)    float64
  2  FLUX            1 ImageHDU         26   (437, 438)    float64
  3  SNR             1 ImageHDU         26   (437, 438)    float64
  4  SNRBIN          1 ImageHDU         26   (437, 438)    float64
  5  XBIN            1 ImageHDU         26   (437, 438)    float64
  6  YBIN            1 ImageHDU         26   (437, 438)    float64
None
```

The other is about the SFH, including `GIRD` for ages and metallicities and `WEIGHTS` for each bin:

```
Filename: IC3392_sfh-weights.fits
No.    Name        Ver    Type       Cards   Dimensions    Format
  0  PRIMARY         1 PrimaryHDU       23   ()
  1  WEIGHTS         1 BinTableHDU      27   4077R x 1C    [477D]
  2  GRID            1 BinTableHDU      31   477R x 3C   [D, D, D]
None
```

The data size makes sense for me. The IC3392 datacube is stacking into a 437×438 map with 4077 voronoi bins. By further examination, I know that each bin has corresponding weights on a 9 (rows of metallicities) $\times$ 53 (columns of ages) SPS grid. The header of `WEIGHTS` also tells me that wavelength range is $4800 - 7000\mathring{A}$ and the SPS template is `MILES`. I also check that in each bin, the `WEIGHTS` are summed up to be 1.

2. Getting the Mass-to-Light ratio

I go the the `MILES` website and find that they provide tables for model predictions:

Magnitudes, colours and mass-to-light ratios

Magnitudes, colours and mass-to-light ratios are provided for the SSPs specified in the table below. For computing the mass-to-light ratios we take into account the remnants and the mass loss during the latest phases of the stellar evolution. It is also important to note that the adopted lower and upper mass cutoffs for all the IMFs are 0.1 and 100 Mo respectively (see Notes), and the faintest star is 0.1 Mo. These model predictions can be obtained from the following files:

Isochrone	[α/Fe]	Unimodal	Bimodal	Kroupa Universal	Kroupa Revised	Chabrier
Padova+00	baseFe	link	link	link	link	link
BaSTI	baseFe	link	link	link	link	link

Each file contain the following columns: (1)IMF type, (2)IMF slope, (3)[M/H], (4)Age, (5)U, (6)B, (7)V, (8)R, (9)I, (10)J, (11)H, (12)K, (13)U-V, (14)B-V, (15)V-R, (16)V-I, (17)V-J, (18)V-H, (19)V-K, (20)(M/L)U, (21)M/L)B, (22)(M/L)V, (23)(M/L)R, (24)(M/L)I, (25)(M/L)J, (26)(M/L)H, (27)(M/L)K, (28)F439W, (29)F555W, (30)F675W, (31)F814W, (32)F439W-F555W, (33)F555W-F675W, (34)F555W-F814W.

HEADER_out_phot includes the appropriate header for these files.

By looking at the Fraser-McKelvie et al. (2024) and checking the exact value in `GRID` data, I think **BaSTI+Chabrier** is the correct one that I should use, so I download the header and table into `BaSTI+Chabrier.dat` and extract the R-band Mass-to-Light ratio (M/L_R).

Now for each bin, I can match the 9×53 METAL-LOGAGE `GRID` with **BaSTI+Chabrier** table to get their M/L_R. Then I dot product the `WEIGHTS` with M/L_R to get effective M/L_R at each bin. And therefore I get M/L_R map and stored it as a new `ImageHDU` called `ML_R` in `IC3392_SPATIAL_BINNING_maps_extended.fits`.

Here I perform a check for a comparison with . Since I also have access to `FLUX` data of each bin, I can compute the flux-weighted mean R-band Mass-to-Light ratio:

$$\overline{M/L_R} = \frac{\Sigma_i^{4077}(M/L_R)_i \cdot F_i}{\Sigma_i^{4077} F_i}. \tag{1}$$

And this gives $\overline{M/L_R} = 1.442 = \log(0.159)$. Recall that the one I get from legacy data with `BC03` template is $1.40 = \log(0.15)$ and the other one I get from `pPXF` with `E-MILES` template is $2.105 = \log(0.323)$. Now here is a question, how can `MILES` one become so close to `BC03` one rather than `E-MILES`.

3. Stellar mass map

To get stellar mass map, I make such assumptions:

1. The distance to IC3392 is 11.5 Mpc
2. $4800 - 7000Å$ is SDSS r-band coverage with effective wavelegth at $6231Å$
3. Solar R-band Magnitude is 4.64

Then I construce the stellar mass map and also save it into an extra array `LOGMSTAR` of `IC3392_SPATIAL_BINNING_maps_extended.fits`.

In this way, the total r band magnitude is 12.323 and total stellar mass is $\log(9.207)$. As a comparison, these values are 11.958 & $\log(9.32)$ in legacy data and 12.369 & $\log(9.355)$ from previous `pPXF`.

Below is the maps I store in `IC3392_SPATIAL_BINNING_maps_extended.fits`. Top left is the stellar mass map, bottom left is the M/L_R map, and the one on the RHS is just the flux.