Synthetic Survey for the Vera Rubin Telescope

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Introduction

Synthetic surveys are a powerful tool in astronomy and astrophysics that allows researchers to compare mathematical tools and models to predetermined data from simulations. Our research aims to create synthetic surveys of simulated Galactic data from the FIRE simulations [1] using the ANANKE software [2]. The surveys will be modeled for the Vera Rubin telescope, which is currently under construction in Chile and will conduct the Legacy Survey of Space and Time (LSST) over the next decade.

Objectives

1. Can we replicate the results of the FIRE simulations using the FIRE-2 public data release?
2. Can we establish the limitations and characteristics of the Vera Rubin telescope, which will be applied to the synthetic survey?
3. Can we translate these characteristics into parameters for our synthetic survey generator, ANANKE?
4. Using the FIRE data, can we apply our modified ANANKE code to generate a final synthetic survey for the Vera Rubin telescope?

Methods

To begin with, we employed the Feedback In Realistic Environments (FIRE) project to import simulation data of Milk-Way-like galaxies. This data is in the form of massive "particles" of 7070 solar mass, which can be separated into different classifications, as shown in figures 2 and 3.

Next, we generated a mock catalog using the ANANKE software, which split the "particles" into individual stars using initial mass functions (IMF). Stellar properties such as luminosity and metallicity were computed from isochrones, while positions and velocities were generated from kernels.

Finally, the ANANKE software converted the mock catalog into a synthetic survey by applying a self-consistent extinction model, a selection function, and error modeling based on the telescope limitations and calibration.
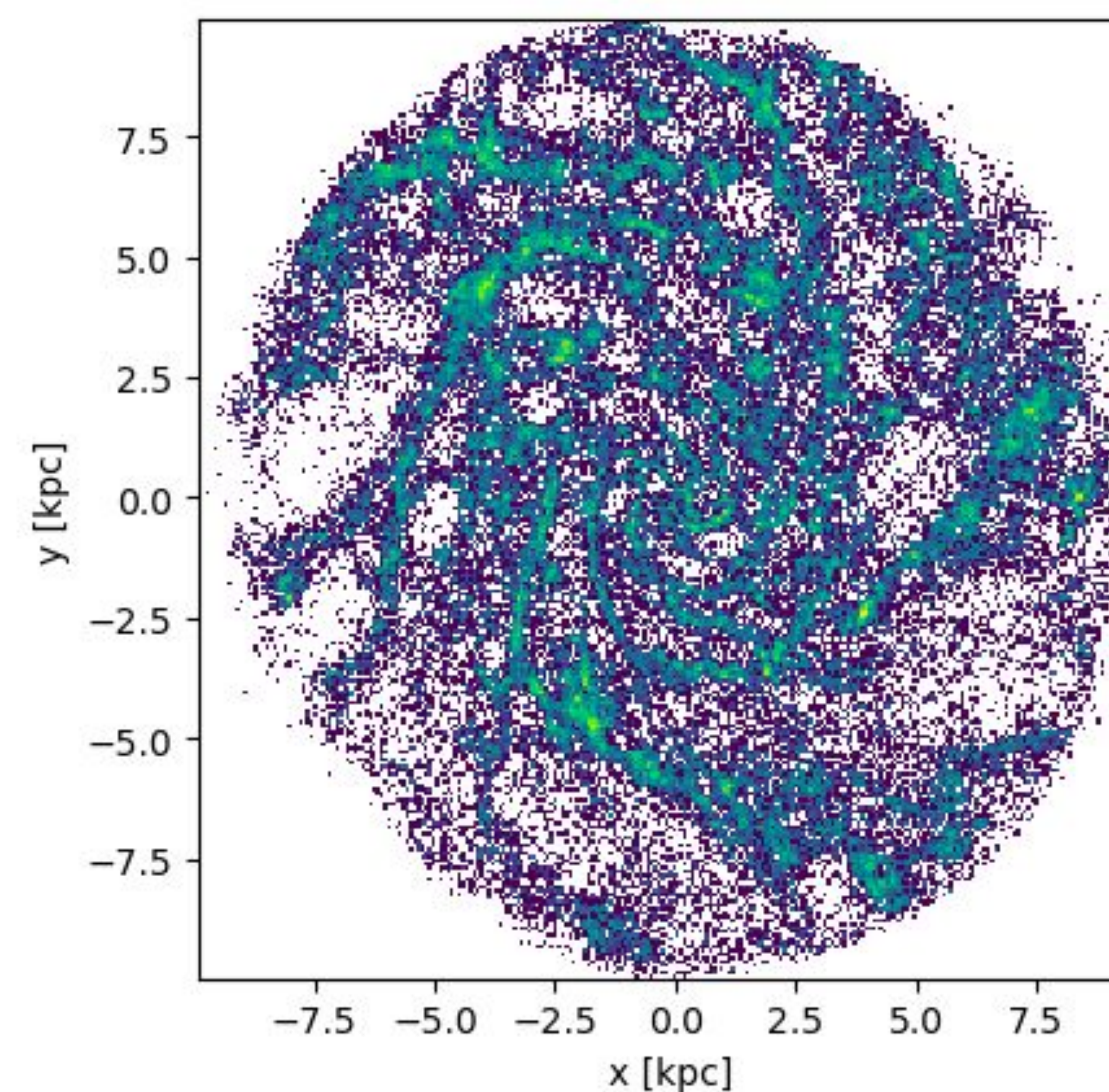

Figure 1: Vera Rubin Telescope

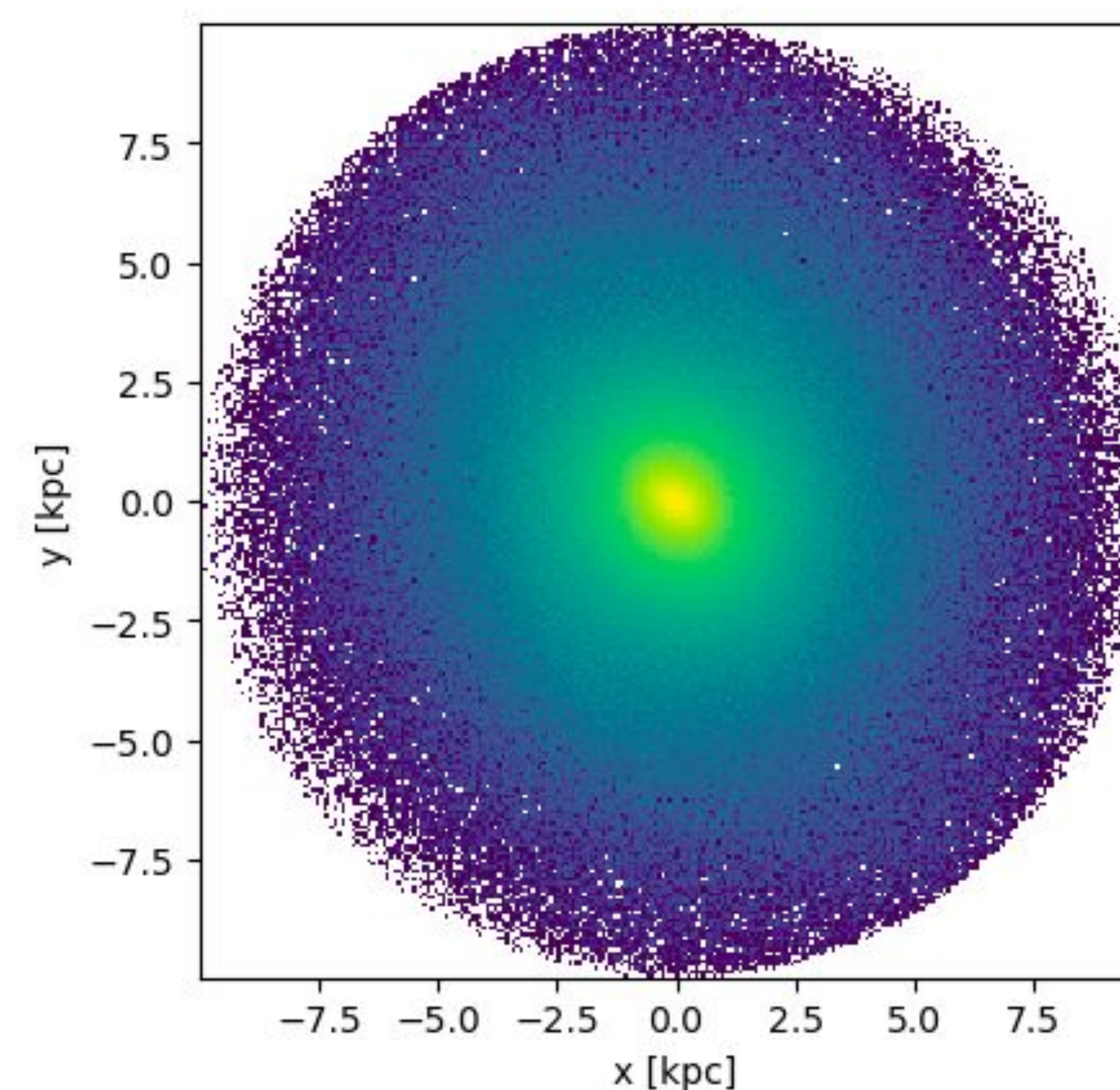**Figure 2: FIRE Gas Distribution**

Figure 3: FIRE Star Distribution

Results

The final output of the code is a synthetic survey of each star as will be viewed by the future Vera Rubin telescope (expected first light August 2024). A truncated version of this dataset is shown in table 1, which contains a reduced dataset to save time and computational resources. This synthetic survey includes many valuable data points, including stellar properties, ages, and locations.

Table 1: Reduced Synthetic Survey

#	age	alpha	dmod	feh	grav	lum
0	4.658994674682617	0.2609992027282715	14.634140543052585	-0.022911779582500458	4.1271915	4.407553
1	4.658994674682617	0.2609992027282715	14.682465495719484	-0.022911779582500458	4.11302	4.475335
2	4.658994674682617	0.2609992027282715	14.727474432841055	-0.022911779582500458	3.9023263	5.10641
3	4.658994674682617	0.2609992027282715	14.582764493439944	-0.022911779582500458	2.5780072	5.7626944
4	4.658994674682617	0.2609992027282715	14.56985694248237	-0.022911779582500458	4.107826	4.498574
...	...	...	...	...	...	...
18,609,718	6.241312503814697	0.310613214969635	18.538232586122276	-0.8433690071105957	4.156208	4.9915586
18,609,719	6.241312503814697	0.310613214969635	18.156149336849293	-0.8433690071105957	4.0862374	5.1772118
18,609,720	6.241312503814697	0.310613214969635	18.35909891817944	-0.8433690071105957	4.0470424	5.259388
18,609,721	7.990084541259766	0.21628527343273163	21.886206196758433	-0.2783314883708954	1.3895739	3.3761313
18,609,722	8.461484909057617	0.3505781888961792	21.448510333060055	-0.44627296924591064	1.5065415	3.010077

Conclusions

Our modified ANANKE software successfully created a practical synthetic survey for the future Vera Rubin telescope using FIRE simulation data. Further work remains to be done to solidify the validity of this survey, and in time it will be judged based on direct observations by the telescope. Future expansion of this project could include incorporating this synthetic survey data into All-Sky Density Maps to explore formation processes in Milky-Way type galaxies.

Acknowledgements

References

[1] Hopkins, P. F., Wetzel, A., Keresˇ, D., et al. 2018, MNRAS, 480, 800
[2] Sanderson, R. E., Wetzel, A., Loebman, S., et al. 2020, ApJS, 246, 6, doi: 10.3847/1538-4365/ab5b9d