1. Accessing the data product:

Lightkurve provides several functions to search for and download observations from Kepler/K2 and TESS. It accesses the data from the MAST archive. To obtain light curve files for your object of interest you can use `search_lightcurve()`

In [10]:
```
#define TIC e.g. TIC 266980320
TIC = 'TIC 284475976' #Confirmed Planet WASP-48b
#search what data is available for a given target
sector_data = lk.search_lightcurve(TIC)
sector_data
```

Out[10]: SearchResult containing 81 data products.

#	mission	year	author	exptime	target_name	distance
				s		arcsec
0	TESS Sector	2019	DIAMANTE	1800	284475976	0.0
1	TESS Sector 14	2019	TESS-SPOC	1800	284475976	0.0
2	TESS Sector 14	2019	QLP	1800	284475976	0.0
3	TESS Sector 14	2019	CDIPS	1800	284475976	0.0
4	TESS Sector 14	2019	TASOC	1800	284475976	0.0
5	TESS Sector 14	2019	TASOC	1800	284475976	0.0
6	TESS Sector 15	2019	TESS-SPOC	1800	284475976	0.0
7	TESS Sector 15	2019	QLP	1800	284475976	0.0
8	TESS Sector 15	2019	CDIPS	1800	284475976	0.0
9	TESS Sector 15	2019	TASOC	1800	284475976	0.0
...	...	...	...	...	...	...
71	TESS Sector 80	2024	QLP	200	284475976	0.0
72	TESS Sector 81	2024	SPOC	20	284475976	0.0
73	TESS Sector 81	2024	SPOC	120	284475976	0.0
74	TESS Sector 81	2024	QLP	200	284475976	0.0
75	TESS Sector 82	2024	SPOC	20	284475976	0.0
76	TESS Sector 82	2024	SPOC	120	284475976	0.0
77	TESS Sector 82	2024	QLP	200	284475976	0.0
78	TESS Sector 83	2024	SPOC	20	284475976	0.0
79	TESS Sector 83	2024	SPOC	120	284475976	0.0
80	TESS Sector 83	2024	QLP	600	284475976	0.0

Length = 81 rows

The above table provides several important pieces of information.

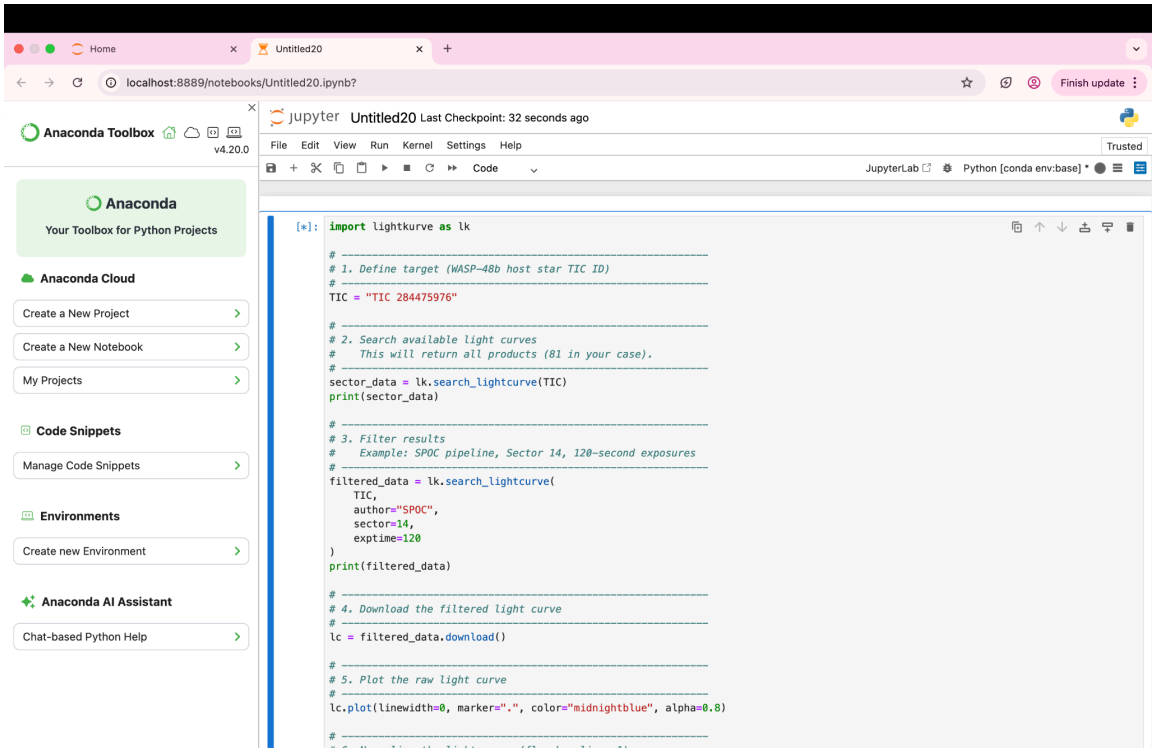
- mission: The specific mission or sector during which the data was collected.
- The year in which the object was observed.
- author: The organization or pipeline that processed the data.

Common authors include:

1. SPOC: Science Processing Operations Center
2. TESS-SPOC: TESS Science Processing Operations Center
3. QLP: Quick Look Pipeline

- exptime: Exposure time, the duration for which each individual measurement was taken, in seconds. For example, "120" means a 120-second exposure.
- The name of the target.
- The distance of the observation from your target of interest.

In [5]:
```
# you can also filter your search using:
#sector_data = lk.search_lightcurve(TIC, author ='SPOC', sector = 3, exptime =120)
```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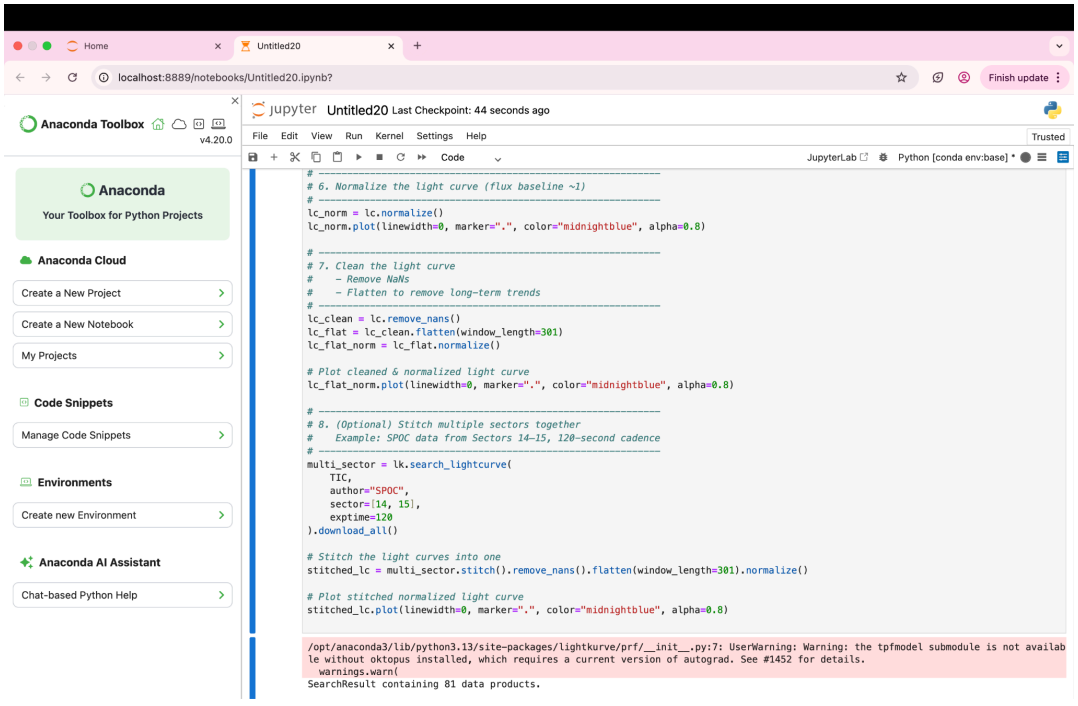
Code
JupyterLab
Python [conda env:base]
[*]:
import lightkurve as lk
# 1. Define target (WASP-48b host star TIC ID)
TIC = "TIC 284475976"
# 2. Search available light curves
# This will return all products (81 in your case).
sector_data = lk.search_lightcurve(TIC)
print(sector_data)
# 3. Filter results
# Example: SPOC pipeline, Sector 14, 120-second exposures
filtered_data = lk.search_lightcurve(
TIC,
author="SPOC",
sector=14,
exptime=120
)
print(filtered_data)
# 4. Download the filtered light curve
lc = filtered_data.download()
# 5. Plot the raw light curve
lc.plot(linewidth=0, marker=".", color="midnightblue", alpha=0.8)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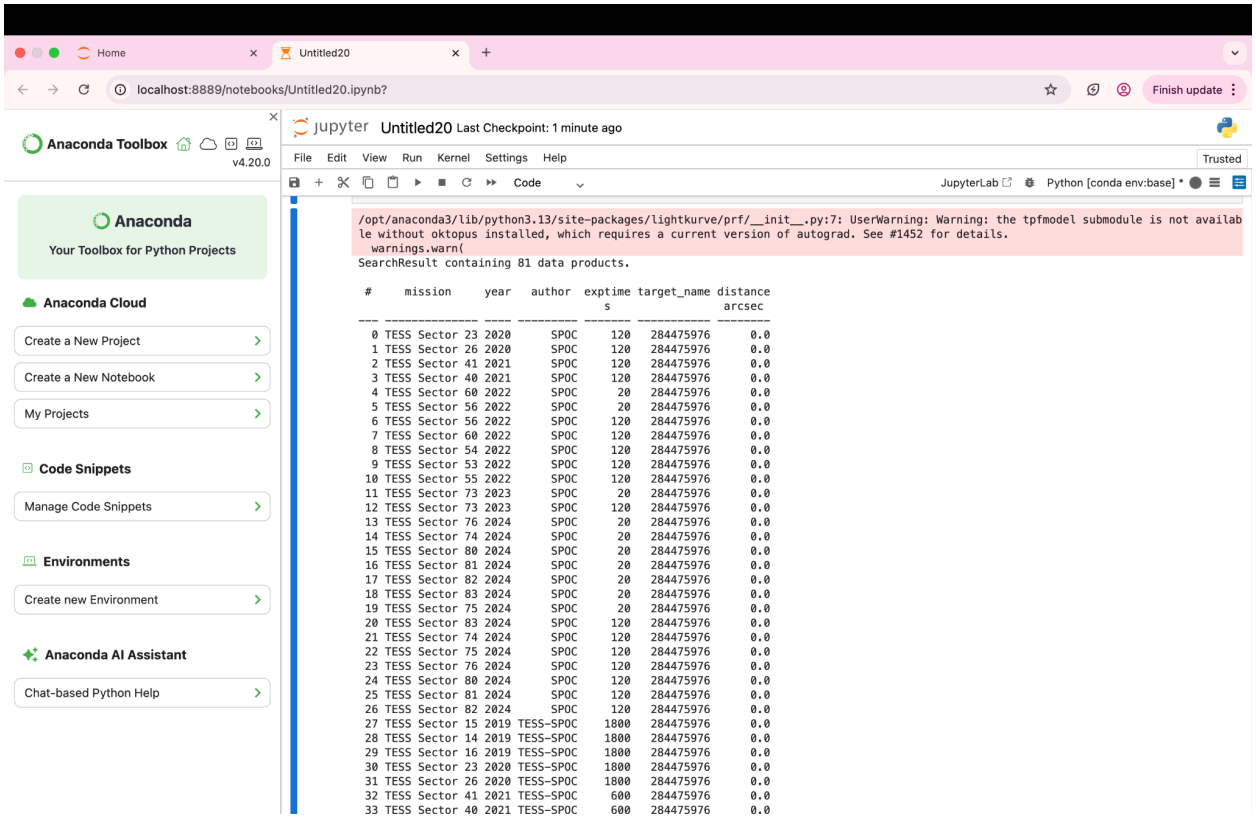
Python [conda env:base]
# 6. Normalize the light curve (flux baseline ~1)
lc_norm = lc.normalize()
lc_norm.plot(linewidth=0, marker=".", color="midnightblue", alpha=0.8)
# 7. Clean the light curve
# - Remove NaNs
# - Flatten to remove long-term trends
lc_clean = lc.remove_nans()
lc_flat = lc_clean.flatten(window_length=301)
lc_flat_norm = lc_flat.normalize()
# Plot cleaned & normalized light curve
lc_flat_norm.plot(linewidth=0, marker=".", color="midnightblue", alpha=0.8)
# 8. (Optional) Stitch multiple sectors together
# Example: SPOC data from Sectors 14-15, 120-second cadence
multi_sector = lk.search_lightcurve(
TIC,
author="SPOC",
sector=[14, 15],
exptime=120
).download_all()
# Stitch the light curves into one
stitched_lc = multi_sector.stitch().remove_nans().flatten(window_length=301).normalize()
# Plot stitched normalized light curve
stitched_lc.plot(linewidth=0, marker=".", color="midnightblue", alpha=0.8)
/opt/anaconda3/lib/python3.13/site-packages/lightkurve/prf/__init__.py:7: UserWarning: Warning: the tpfmodel submodule is not availab
le without oktopus installed, which requires a current version of autograd. See #1452 for details.
warnings.warn(
SearchResult containing 81 data products.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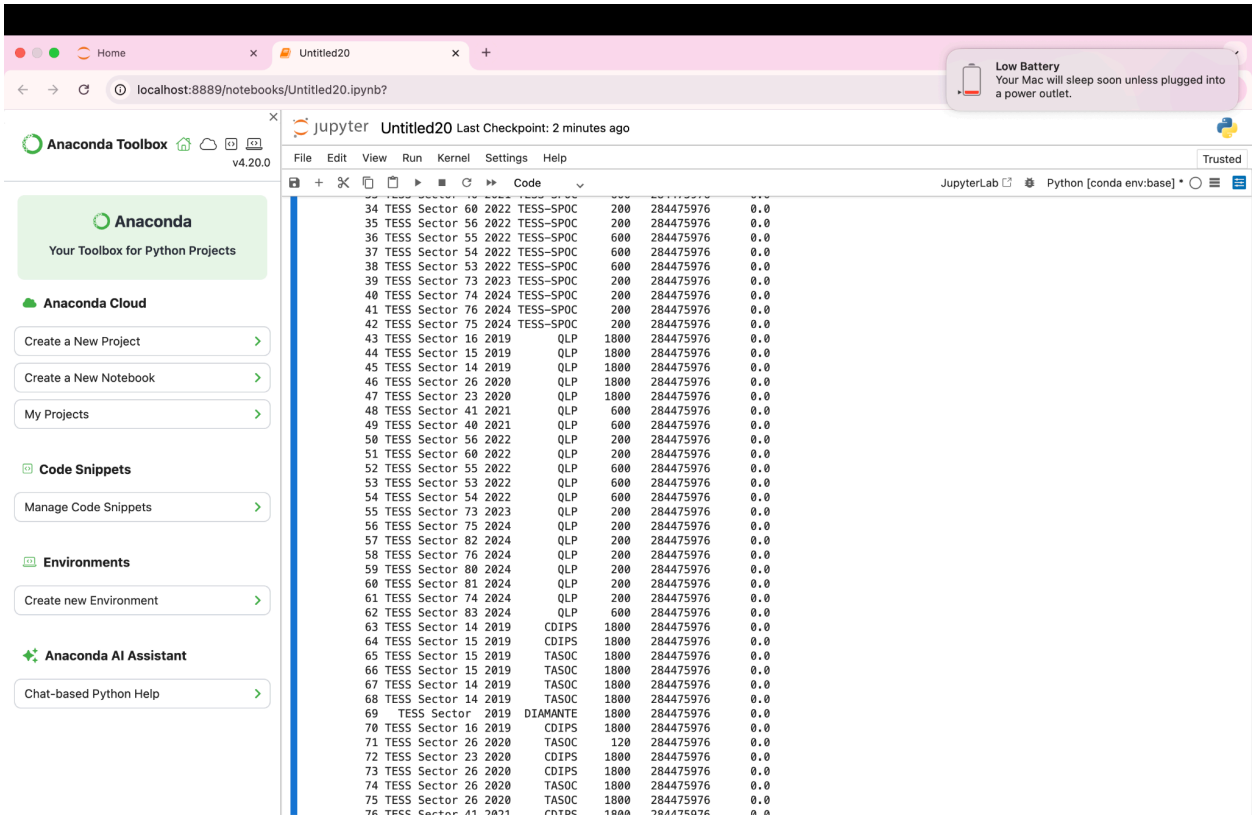
le without oktopus installed, which requires a current version of autograd. See #1452 for details.
warnings.warn(
SearchResult containing 81 data products.
mission year author exptime target_name distance
s arcsec
0 TESS Sector 23 2020 SPOC 120 284475976 0.0
1 TESS Sector 26 2020 SPOC 120 284475976 0.0
2 TESS Sector 41 2021 SPOC 120 284475976 0.0
3 TESS Sector 40 2021 SPOC 120 284475976 0.0
4 TESS Sector 60 2022 SPOC 20 284475976 0.0
5 TESS Sector 56 2022 SPOC 20 284475976 0.0
6 TESS Sector 56 2022 SPOC 120 284475976 0.0
7 TESS Sector 60 2022 SPOC 120 284475976 0.0
8 TESS Sector 54 2022 SPOC 120 284475976 0.0
9 TESS Sector 53 2022 SPOC 120 284475976 0.0
10 TESS Sector 55 2022 SPOC 120 284475976 0.0
11 TESS Sector 73 2023 SPOC 20 284475976 0.0
12 TESS Sector 73 2023 SPOC 120 284475976 0.0
13 TESS Sector 76 2024 SPOC 20 284475976 0.0
14 TESS Sector 74 2024 SPOC 20 284475976 0.0
15 TESS Sector 80 2024 SPOC 20 284475976 0.0
16 TESS Sector 81 2024 SPOC 20 284475976 0.0
17 TESS Sector 82 2024 SPOC 20 284475976 0.0
18 TESS Sector 83 2024 SPOC 20 284475976 0.0
19 TESS Sector 75 2024 SPOC 20 284475976 0.0
20 TESS Sector 83 2024 SPOC 120 284475976 0.0
21 TESS Sector 74 2024 SPOC 120 284475976 0.0
22 TESS Sector 75 2024 SPOC 120 284475976 0.0
23 TESS Sector 76 2024 SPOC 120 284475976 0.0
24 TESS Sector 80 2024 SPOC 120 284475976 0.0
25 TESS Sector 81 2024 SPOC 120 284475976 0.0
26 TESS Sector 82 2024 SPOC 120 284475976 0.0
27 TESS Sector 15 2019 TESS-SPOC 1800 284475976 0.0
28 TESS Sector 14 2019 TESS-SPOC 1800 284475976 0.0
29 TESS Sector 16 2019 TESS-SPOC 1800 284475976 0.0
30 TESS Sector 23 2020 TESS-SPOC 1800 284475976 0.0
31 TESS Sector 26 2020 TESS-SPOC 1800 284475976 0.0
32 TESS Sector 41 2021 TESS-SPOC 600 284475976 0.0
33 TESS Sector 40 2021 TESS-SPOC 600 284475976 0.0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Python [conda env:base]
34 TESS Sector 60 2022 TESS-SPOC 200 284475976 0.0
35 TESS Sector 56 2022 TESS-SPOC 200 284475976 0.0
36 TESS Sector 55 2022 TESS-SPOC 600 284475976 0.0
37 TESS Sector 54 2022 TESS-SPOC 600 284475976 0.0
38 TESS Sector 53 2022 TESS-SPOC 600 284475976 0.0
39 TESS Sector 73 2023 TESS-SPOC 200 284475976 0.0
40 TESS Sector 74 2024 TESS-SPOC 200 284475976 0.0
41 TESS Sector 76 2024 TESS-SPOC 200 284475976 0.0
42 TESS Sector 75 2024 TESS-SPOC 200 284475976 0.0
43 TESS Sector 16 2019 QLP 1800 284475976 0.0
44 TESS Sector 15 2019 QLP 1800 284475976 0.0
45 TESS Sector 14 2019 QLP 1800 284475976 0.0
46 TESS Sector 26 2020 QLP 1800 284475976 0.0
47 TESS Sector 23 2020 QLP 1800 284475976 0.0
48 TESS Sector 41 2021 QLP 600 284475976 0.0
49 TESS Sector 40 2021 QLP 600 284475976 0.0
50 TESS Sector 56 2022 QLP 200 284475976 0.0
51 TESS Sector 60 2022 QLP 200 284475976 0.0
52 TESS Sector 55 2022 QLP 600 284475976 0.0
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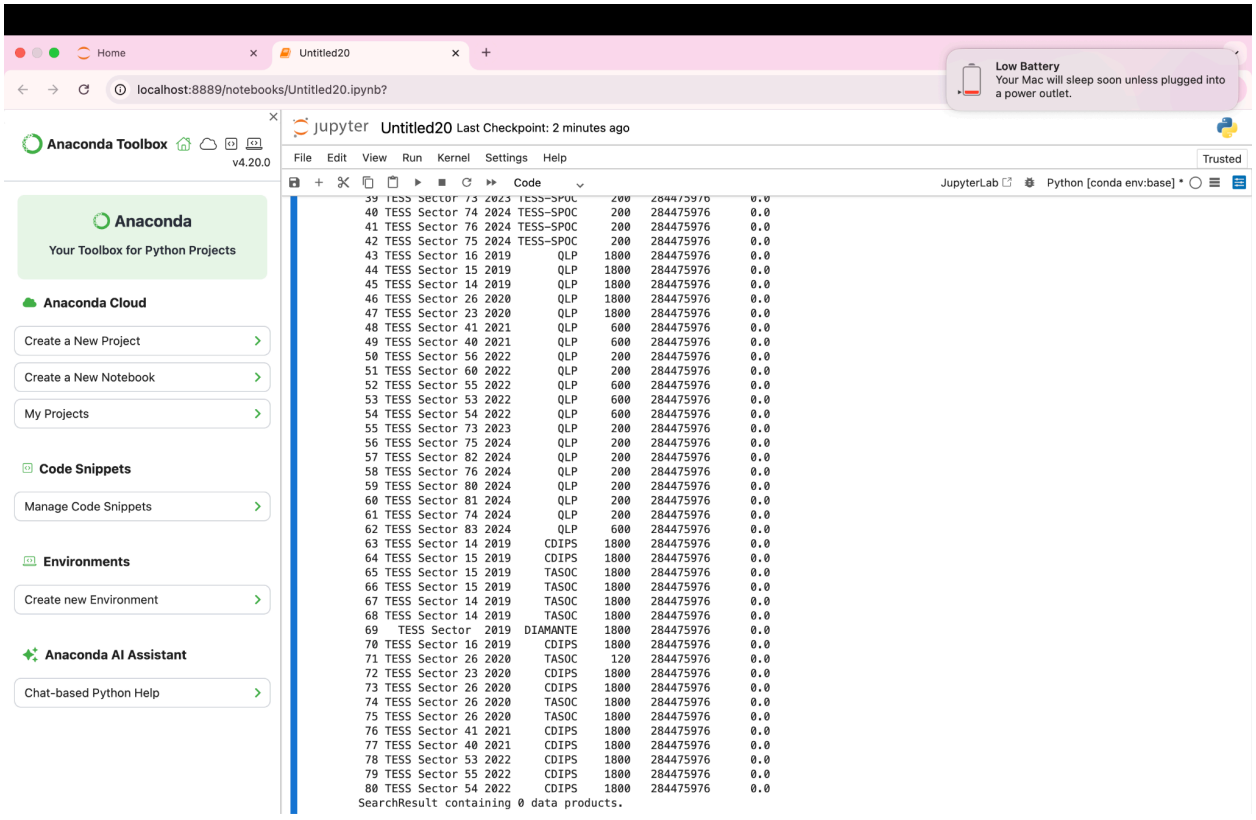
54 TESS Sector 54 2022 QLP 600 284475976 0.0
55 TESS Sector 73 2023 QLP 200 284475976 0.0
56 TESS Sector 75 2024 QLP 200 284475976 0.0
57 TESS Sector 82 2024 QLP 200 284475976 0.0
58 TESS Sector 76 2024 QLP 200 284475976 0.0
59 TESS Sector 80 2024 QLP 200 284475976 0.0
60 TESS Sector 81 2024 QLP 200 284475976 0.0
61 TESS Sector 74 2024 QLP 200 284475976 0.0
62 TESS Sector 83 2024 QLP 600 284475976 0.0
63 TESS Sector 14 2019 CDIPS 1800 284475976 0.0
64 TESS Sector 15 2019 CDIPS 1800 284475976 0.0
65 TESS Sector 15 2019 TASOC 1800 284475976 0.0
66 TESS Sector 15 2019 TASOC 1800 284475976 0.0
67 TESS Sector 14 2019 TASOC 1800 284475976 0.0
68 TESS Sector 14 2019 TASOC 1800 284475976 0.0
69 TESS Sector 2019 DIAMANTE 1800 284475976 0.0
70 TESS Sector 16 2019 CDIPS 1800 284475976 0.0
71 TESS Sector 26 2020 TASOC 120 284475976 0.0
72 TESS Sector 23 2020 CDIPS 1800 284475976 0.0
73 TESS Sector 26 2020 CDIPS 1800 284475976 0.0
74 TESS Sector 26 2020 TASOC 1800 284475976 0.0
75 TESS Sector 26 2020 TASOC 1800 284475976 0.0

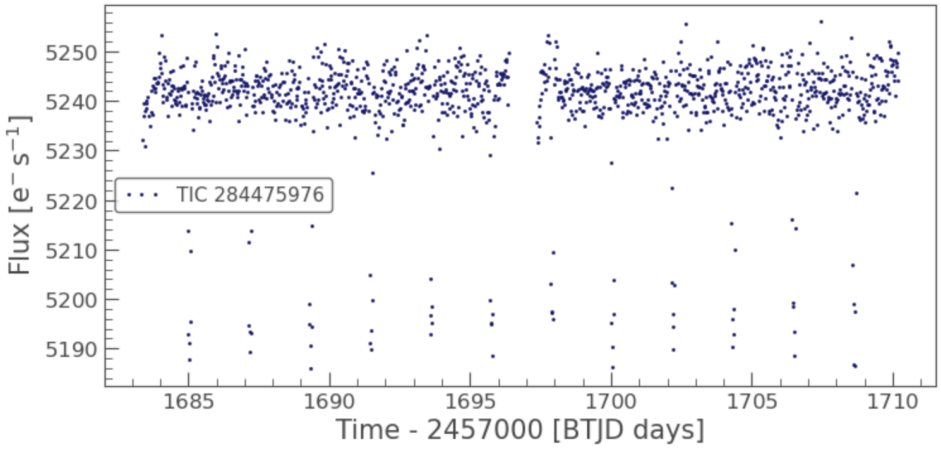


2. Download the data and plot the light curve

Once you've identified the sectors you're interested in, you can download the corresponding light curve data using the download method. This method returns a LightCurve object that contains the downloaded data.

In [11]:
```
#plot the lightcurve to see what it looks like
lc = sector_data[1].download()
lc.plot(linewidth= 0, marker = '.', color = 'midnightblue', alpha = 2 )
```

Out[11]: <AxesSubplot:xlabel='Time - 2457000 [BTJD days]', ylabel='Flux [$\\mathrm{e^{-}\\,s^{-1}}$]'>

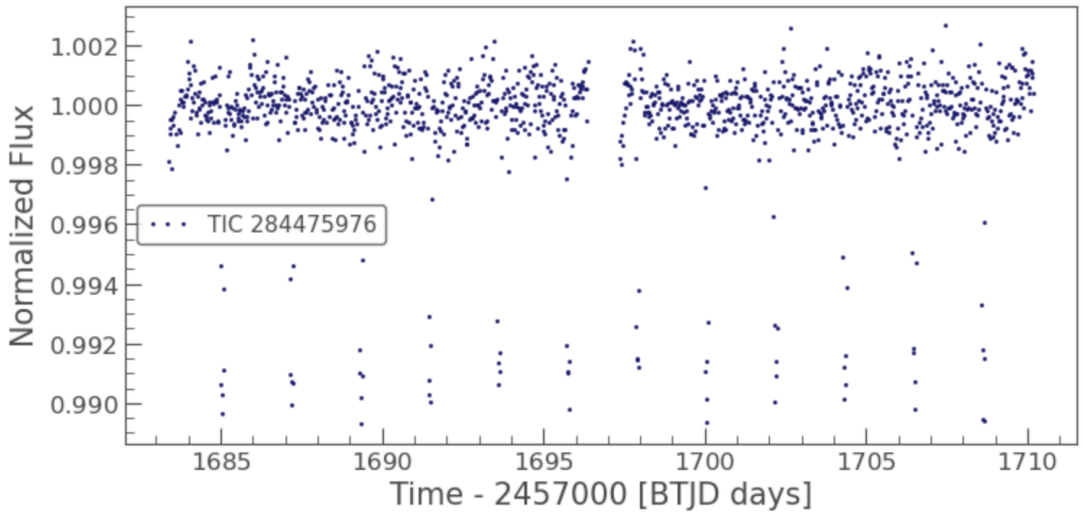


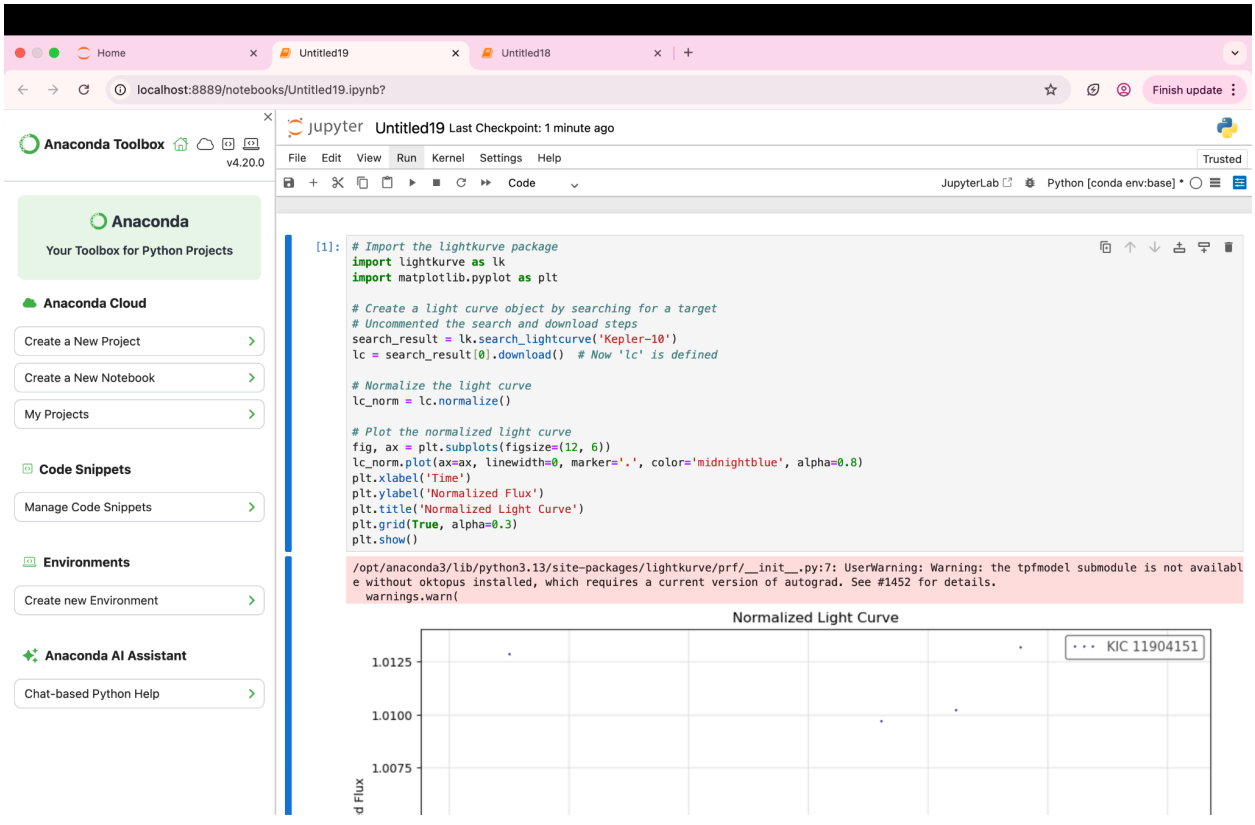
The plot may look like this and the light curve might not that be obvious and require further processing.

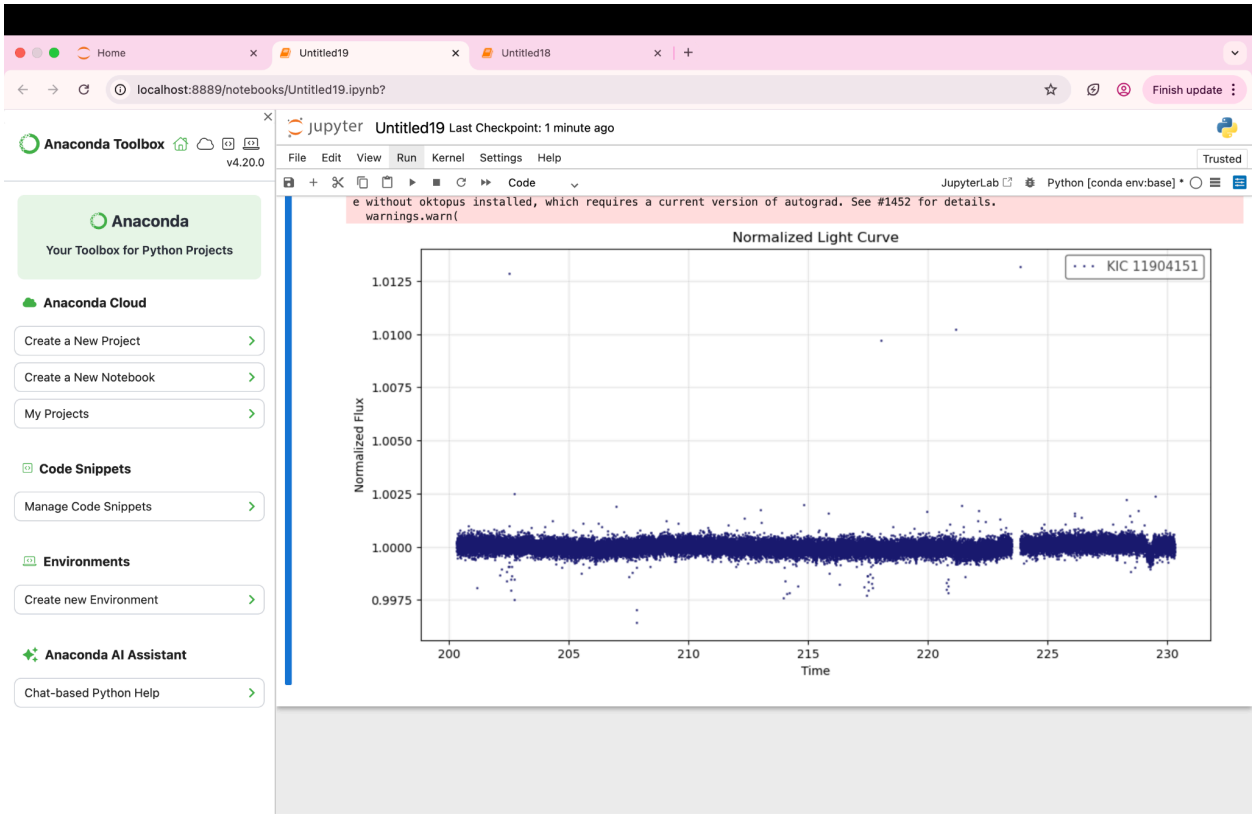
Normalization Involves adjusting the light curve data so that the variations in brightness are scaled relative to a baseline level, ie 1 or 0. This process makes it easier to compare different light curves and to identify patterns or anomalies

In [12]:
```
lc_norm = lc.normalize()
lc_norm.plot(linewidth= 0, marker = '.', color = 'midnightblue', alpha = 2 )
```

Out[12]: <AxesSubplot:xlabel='Time - 2457000 [BTJD days]', ylabel='Normalized Flux'>







3. Manipulating the Light Curve

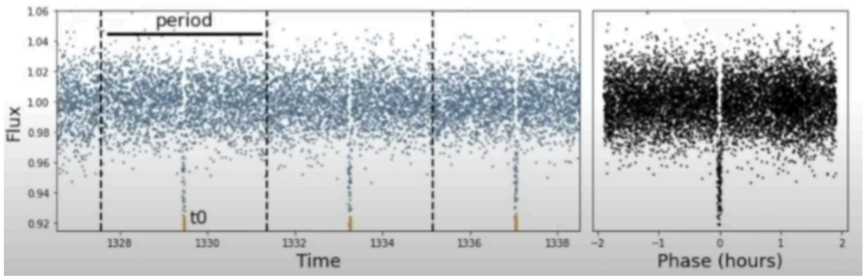
There are a set of useful functions in *Lightkurve* which you can use to work with the data. It can significantly improve the quality and interpretability of the data. These include:

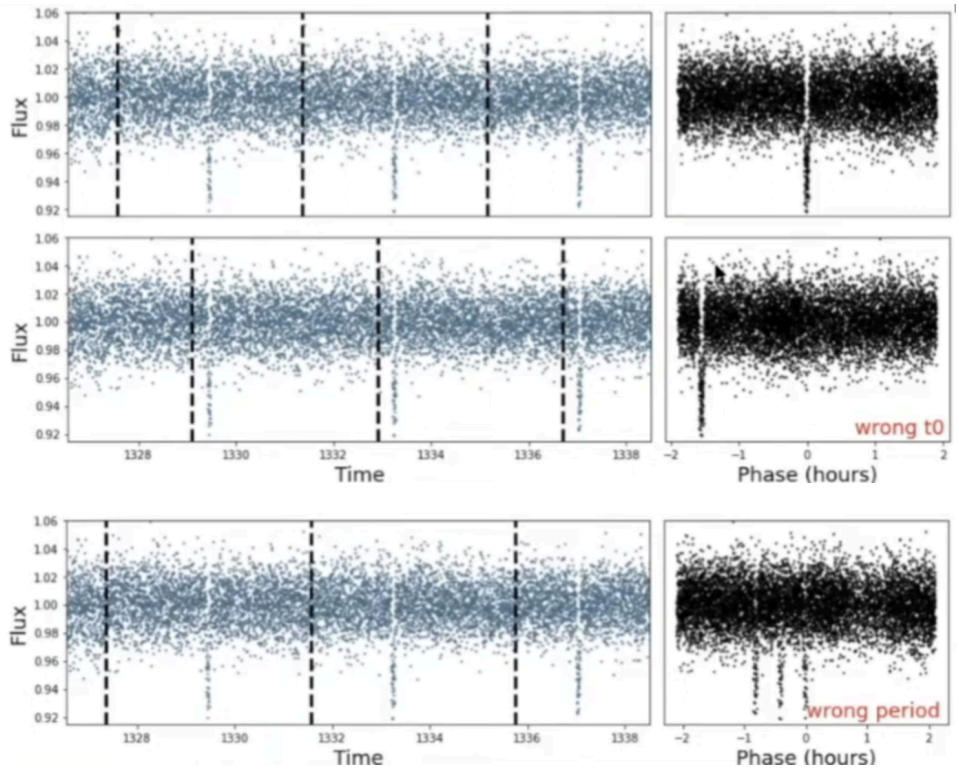
- flatten(): Flattening removes the low-frequency trend from the light curve using a Savitzky-Golay filter. This is useful for highlighting shorter-term variability.
- remove_outliers():Outlier removal helps in cleaning the data by eliminating points that deviate significantly from the rest of the distribution.
- remove_nans(): Remove infinite or NaN values
- fold(): Fold the data at a particular period
- bin(): Reduce the time resolution of the array, taking the average value in each bin.

Phase Folding

Returns a Folded Light Curve object folded on a period and epoch. Used to find the transit in the data.

In phase folding you make periodic cuts and put these multiple transits on top of each other to build up more signal. The more data we have the better we can characterize the transit.



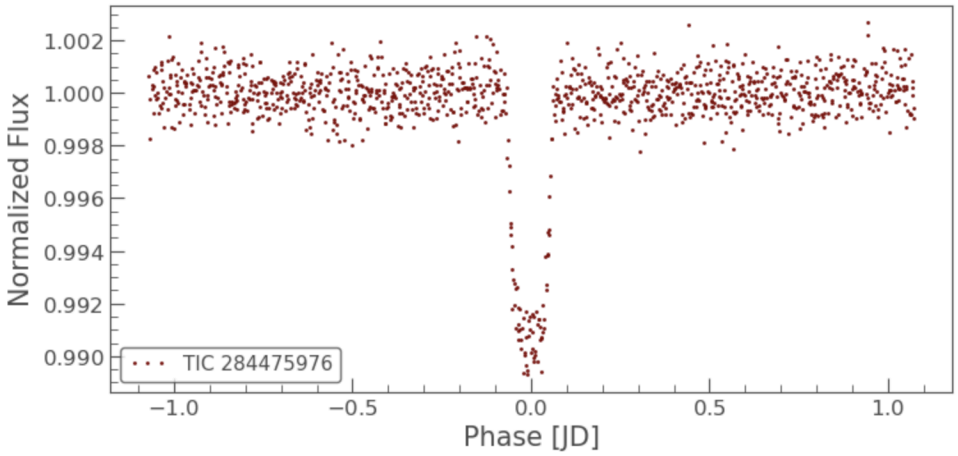


You can determine the epoch time and orbital period of the target from the ExoFOP website.

You can determine the epoch time and orbital period of the target from the ExoFOP website.

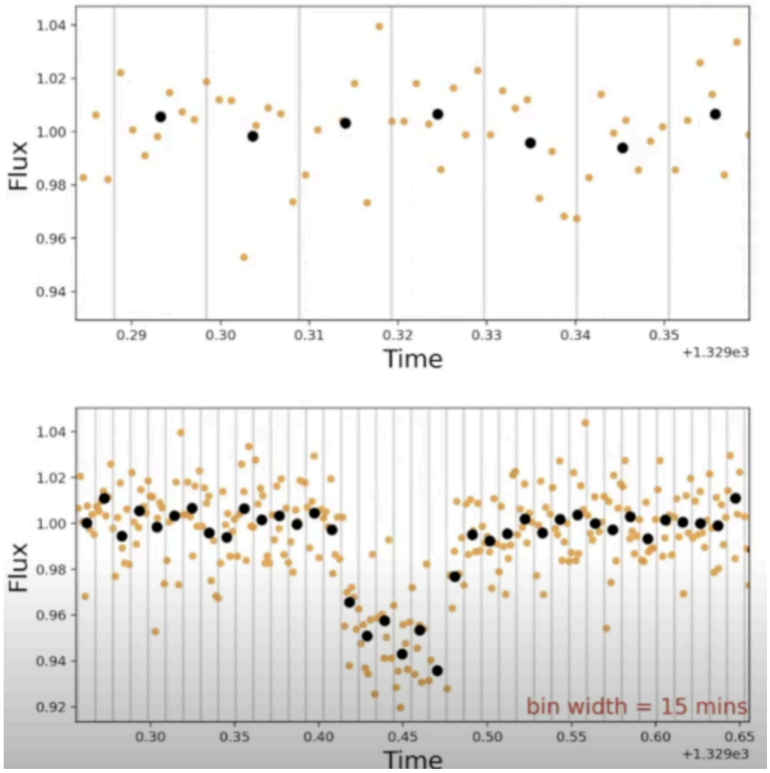
In [13]:
```
t0 = 2825.459527
period = 2.14363
lc_phased = lc_norm.fold(period = period, epoch_time = t0)
lc_phased.plot(linewidth =0, color = 'maroon', marker='.', alpha=2 )
#plt.xlim(-2,2)
```

Out[13]: <AxesSubplot:xlabel='Phase [JD]', ylabel='Normalized Flux'>



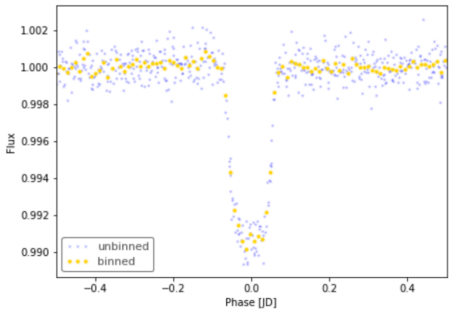
Binning

Binnning in lightcurve plotting refers to the process of combining data points within a specified time interval to reduce noise and smooth out the data.



In [9]:
```
lc_phased_binned = lc_phased.bin (15/24/60) #bin width =15 mins. it has to be in terms of minutes when using Ligh
fig, ax = plt.subplots (figsize = (7,5))
lc_phased.plot(ax = ax, marker = '.', linewidth = 0, color = 'blue', alpha = 0.2, markersize = 3, label = "unbinn
lc_phased_binned.plot(ax= ax, marker = 'o', linewidth= 0, color = 'gold', alpha = 1, markersize = 3, label = "bin
plt.xlim(-0.5,0.5)
```

Out[9]: (-0.5, 0.5)



How to find the best TIC ID:

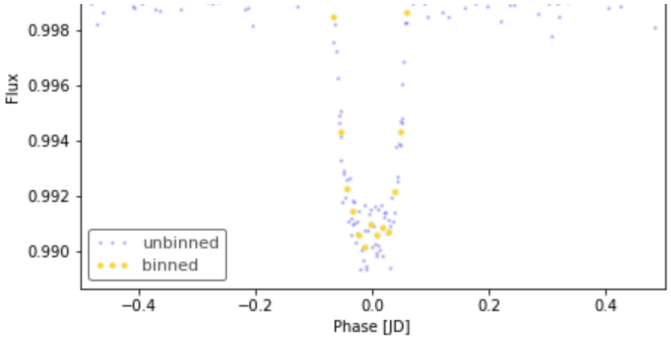
- Exoplanet Archive TOI List
- TOI Catalog

Use TESS ExoFOP and other data sources to validate the information.

Try for Yourself!!

To dive deeper follow these links:

- STScI TESS Workshop
- Lightkurve Tutorials



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- Lightkurve Tutorials
- STSci Data Search Tutorials

REFERENCES:

- https://heasarc.gsfc.nasa.gov/docs/tess/TESS-Intro.html
- https://planethunters.coffee/

In [ ]:

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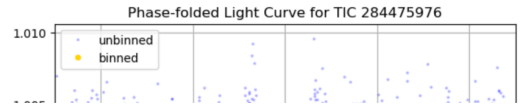
[2]:
```
import lightkurve as lk
import matplotlib.pyplot as plt

search_result = lk.search_lightcurve('TIC 284475976', author='SPOC', cadence='short')
lc = search_result.download().normalize()  # normalize sets flux to around 1.0

lc_clean = lc.remove_nans().remove_outliers().flatten()

t0 = 2825.459527           # epoch time in BJD
period = 2.14363           # period in days

lc_phased = lc_clean.fold(period=period, epoch_time=t0)

lc_phased_binned = lc_phased.bin(15 / (24 * 60))  # 15 minutes bin

fig, ax = plt.subplots(figsize=(7, 5))
lc_phased.plot(ax=ax, marker='.', linewidth=0, color='blue', alpha=0.2, markersize=3, label="unbinned")
lc_phased_binned.plot(ax=ax, marker='o', linewidth=0, color='gold', alpha=1, markersize=4, label="binned")
plt.xlim(-0.5, 0.5)
plt.xlabel("Phase [days]")
plt.ylabel("Normalized Flux")
plt.legend()
plt.title("Phase-folded Light Curve for TIC 284475976")
plt.grid(True)
plt.show()
```

```
/opt/anaconda3/lib/python3.13/site-packages/lightkurve/search.py:420: LightkurveWarning: Warning: 17 files available to download. Only the first file has been downloaded. Please use `download_all()` or specify additional criteria (e.g. quarter, campaign, or sector) to limit your search.
  warnings.warn(
```



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/opt/anaconda3/lib/python3.13/site-packages/lightkurve/search.py:420: LightkurveWarning: Warning: 17 files available to download. Only the first file has been downloaded. Please use `download_all()` or specify additional criteria (e.g. quarter, campaign, or sector) to limit your search.
  warnings.warn(