Annotate plots

The following examples show ways to annotate plots in Matplotlib. This includes highlighting specific points of interest and using various visual tools to call attention to this point. For a more complete and in-depth description of the annotation and text tools in Matplotlib, see the tutorial on annotation.

```
import matplotlib.pyplot as plt
import numpy as np

from matplotlib.patches import Ellipse
from matplotlib.text import OffsetFrom
```

Specifying text points and annotation points

You must specify an annotation point `xy=(x, y)` to annotate this point. Additionally, you may specify a text point `xytext=(x, y)` for the location of the text for this annotation. Optionally, you can specify the coordinate system of *xy* and *xytext* with one of the following strings for *xycoords* and *textcoords* (default is 'data'):

```
'figure points'   : points from the lower left corner of the figure
'figure pixels'   : pixels from the lower left corner of the figure
'figure fraction' : (0, 0) is lower left of figure and (1, 1) is upper right
'axes points'     : points from lower left corner of the Axes
'axes pixels'     : pixels from lower left corner of the Axes
'axes fraction'   : (0, 0) is lower left of Axes and (1, 1) is upper right
'offset points'   : Specify an offset (in points) from the xy value
'offset pixels'   : Specify an offset (in pixels) from the xy value
'data'            : use the Axes data coordinate system
```

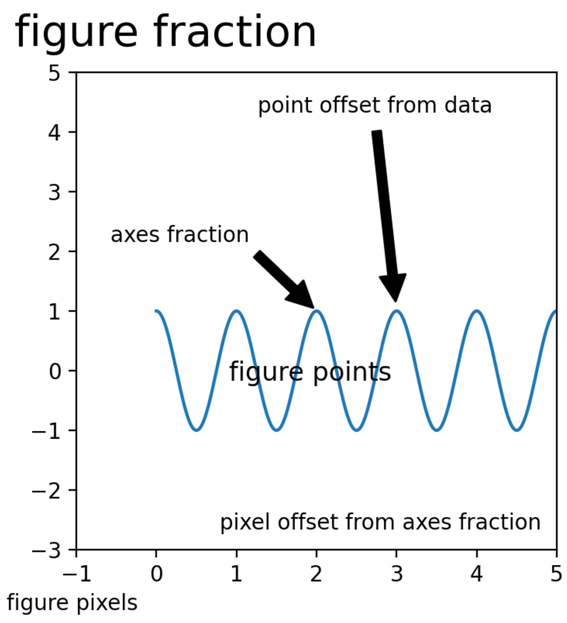
Note: for physical coordinate systems (points or pixels) the origin is the (bottom, left) of the figure or Axes.

Optionally, you can specify arrow properties which draws and arrow from the text to the annotated point by giving a dictionary of arrow properties

Valid keys are:

```
width : the width of the arrow in points
frac  : the fraction of the arrow length occupied by the head
headwidth : the width of the base of the arrow head in points
shrink : move the tip and base some percent away from the
         annotated point and text
any key for matplotlib.patches.polygon  (e.g., facecolor)
```

```
# Create our figure and data we'll use for plotting
fig, ax = plt.subplots(figsize=(4, 4))

t = np.arange(0.0, 5.0, 0.01)
s = np.cos(2*np.pi*t)

# Plot a line and add some simple annotations
line, = ax.plot(t, s)
ax.annotate('figure pixels',
            xy=(10, 10), xycoords='figure pixels')
ax.annotate('figure points',
            xy=(107, 110), xycoords='figure points',
            fontsize=12)
ax.annotate('figure fraction',
            xy=(.025, .975), xycoords='figure fraction',
            horizontalalignment='left', verticalalignment='top',
            fontsize=20)

# The following examples show off how these arrows are drawn.

ax.annotate('point offset from data',
            xy=(3, 1), xycoords='data',
            xytext=(-10, 90), textcoords='offset points',
            arrowprops=dict(facecolor='black', shrink=0.05),
            horizontalalignment='center', verticalalignment='bottom')

ax.annotate('axes fraction',
            xy=(2, 1), xycoords='data',
            xytext=(0.36, 0.68), textcoords='axes fraction',
            arrowprops=dict(facecolor='black', shrink=0.05),
            horizontalalignment='right', verticalalignment='top')

# You may also use negative points or pixels to specify from (right, top).
# E.g., (-10, 10) is 10 points to the left of the right side of the Axes and 10
# points above the bottom

ax.annotate('pixel offset from axes fraction',
            xy=(1, 0), xycoords='axes fraction',
            xytext=(-20, 20), textcoords='offset pixels',
            horizontalalignment='right',
            verticalalignment='bottom')

ax.set(xlim=(-1, 5), ylim=(-3, 5))
```

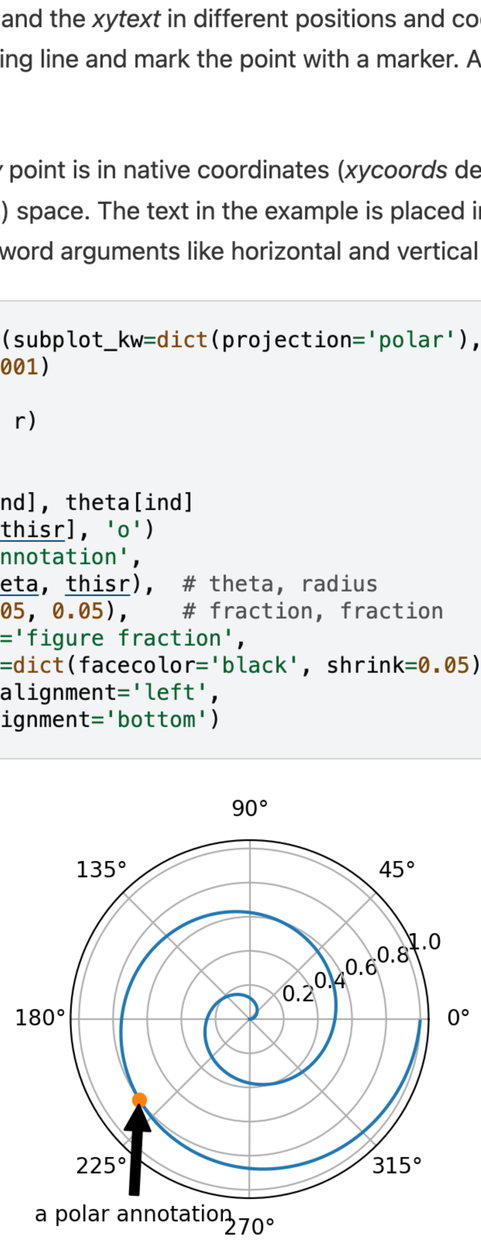


Using multiple coordinate systems and axis types

You can specify the *xypoint* and the *xytext* in different positions and coordinate systems, and optionally turn on a connecting line and mark the point with a marker. Annotations work on polar Axes too.

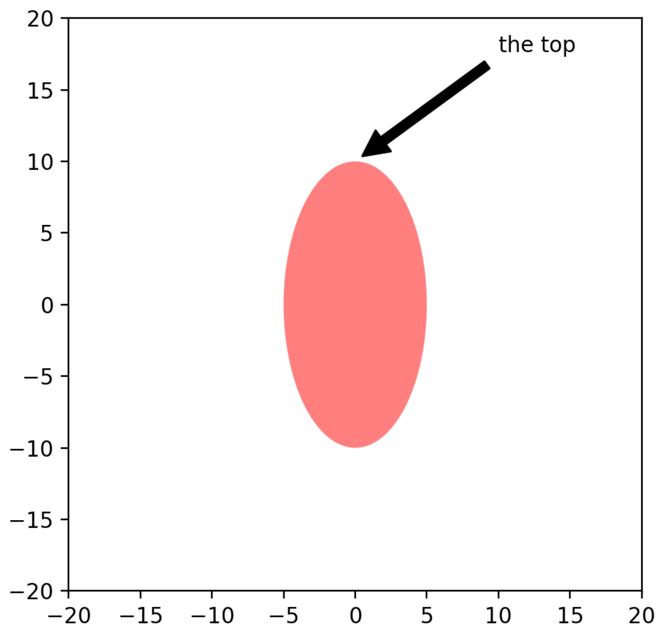
In the example below, the *xy* point is in native coordinates (*xycoords* defaults to 'data'). For a polar Axes, this is in (theta, radius) space. The text in the example is placed in the fractional figure coordinate system. Text keyword arguments like horizontal and vertical alignment are respected.

```
fig, ax = plt.subplots(subplot_kw=dict(projection='polar'), figsize=(3, 3))
r = np.arange(0, 1, 0.001)
theta = 2*2*np.pi*r
line, = ax.plot(theta, r)

ind = 800
thisr, thistheta = r[ind], theta[ind]
ax.plot([thistheta], [thisr], 'o')
ax.annotate('a polar annotation',
            xy=(thistheta, thisr),  # theta, radius
            xytext=(0.05, 0.05),    # fraction, fraction
            textcoords='figure fraction',
            arrowprops=dict(facecolor='black', shrink=0.05),
            horizontalalignment='left',
            verticalalignment='bottom')
```



You can also use polar notation on a cartesian Axes. Here the native coordinate system ('data') is cartesian, so you need to specify the xycoords and textcoords as 'polar' if you want to use (theta, radius).

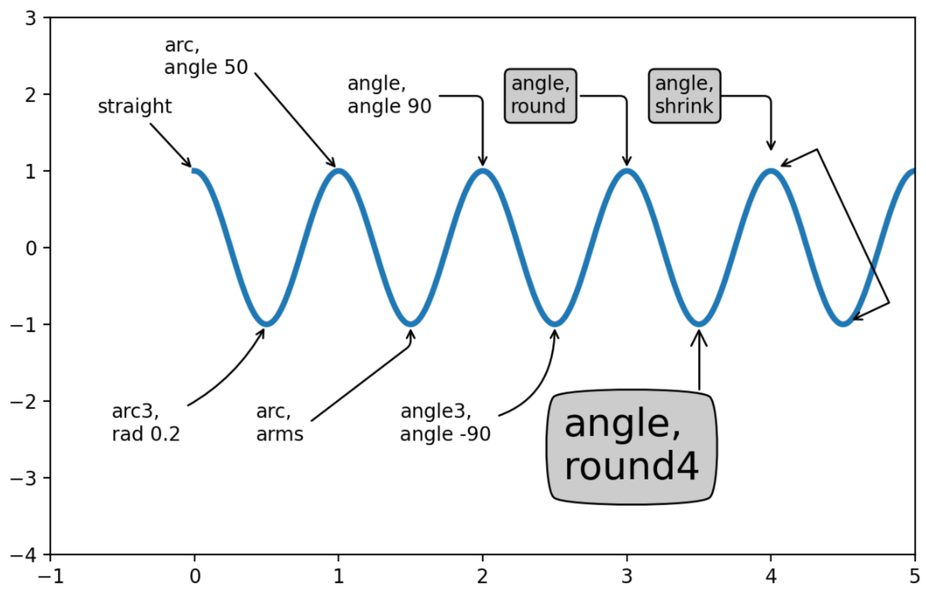
```
el = Ellipse((0, 0), 10, 20, facecolor='r', alpha=0.5)

fig, ax = plt.subplots(subplot_kw=dict(aspect='equal'))
ax.add_artist(el)
el.set_clip_box(ax.bbox)
ax.annotate('the top',
            xy=(np.pi/2., 10.),      # theta, radius
            xytext=(np.pi/3, 20.),   # theta, radius
            xycoords='polar',
            textcoords='polar',
            arrowprops=dict(facecolor='black', shrink=0.05),
            horizontalalignment='left',
            verticalalignment='bottom',
            clip_on=True)  # clip to the Axes bounding box

ax.set(xlim=[-20, 20], ylim=[-20, 20])
```



Customizing arrow and bubble styles

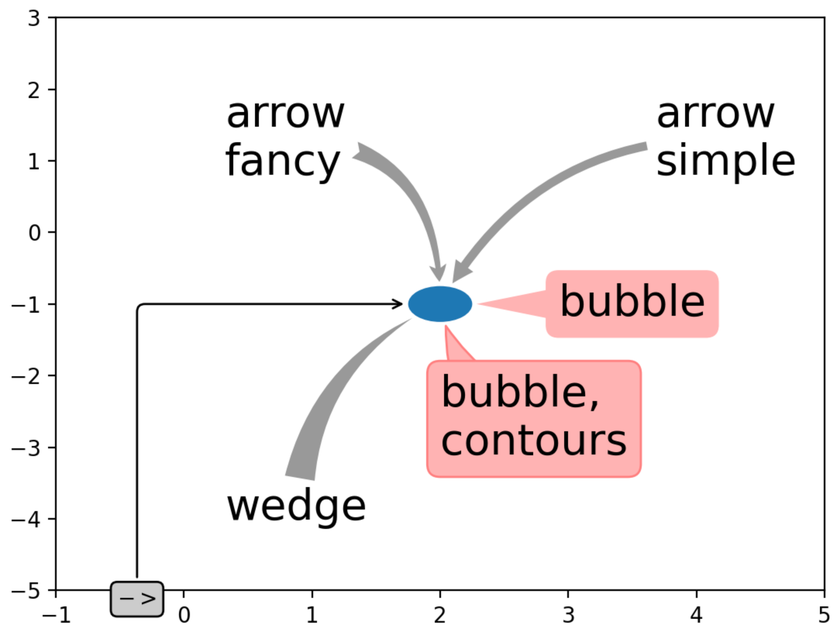
The arrow between *xytext* and the annotation point, as well as the bubble that covers the annotation text, are highly customizable. Below are a few parameter options as well as their resulting output.

```
fig, ax = plt.subplots(figsize=(8, 5))

t = np.arange(0.0, 5.0, 0.01)
s = np.cos(2*np.pi*t)
line, = ax.plot(t, s, lw=3)

ax.annotate(
    'straight',
    xy=(0, 1), xycoords='data',
    xytext=(-50, 30), textcoords='offset points',
    arrowprops=dict(arrowstyle="->"))
ax.annotate(
    'arc3,\nrad 0.2',
    xy=(0.5, -1), xycoords='data',
    xytext=(-80, -60), textcoords='offset points',
    arrowprops=dict(arrowstyle="->",
                    connectionstyle="arc3,rad=.2"))
ax.annotate(
    'arc,\nangle 50',
    xy=(1., 1), xycoords='data',
    xytext=(-90, 50), textcoords='offset points',
    arrowprops=dict(arrowstyle="->",
                    connectionstyle="arc,angleA=0,armA=50,rad=10"))
ax.annotate(
    'arc,\narms',
    xy=(1.5, -1), xycoords='data',
    xytext=(-80, -60), textcoords='offset points',
    arrowprops=dict(
        arrowstyle="->",
        connectionstyle="arc,angleA=0,armA=40,angleB=-90,armB=30,rad=7"))
ax.annotate(
    'angle,\nangle 90',
    xy=(2., 1), xycoords='data',
    xytext=(-70, 30), textcoords='offset points',
    arrowprops=dict(arrowstyle="->",
                    connectionstyle="angle,angleA=0,angleB=90,rad=10"))
ax.annotate(
    'angle3,\nangle -90',
    xy=(2.5, -1), xycoords='data',
    xytext=(-80, -60), textcoords='offset points',
    arrowprops=dict(arrowstyle="->",
                    connectionstyle="angle3,angleA=0,angleB=-90"))
ax.annotate(
    'angle,\nround',
    xy=(3., 1), xycoords='data',
    xytext=(-60, 30), textcoords='offset points',
    bbox=dict(boxstyle="round", fc="0.8"),
    arrowprops=dict(arrowstyle="->",
                    connectionstyle="angle,angleA=0,angleB=90,rad=10"))
ax.annotate(
    'angle,\nround4',
    xy=(3.5, -1), xycoords='data',
    xytext=(-70, -80), textcoords='offset points',
    size=20,
    bbox=dict(boxstyle="round4,pad=.5", fc="0.8"),
    arrowprops=dict(arrowstyle="->",
                    connectionstyle="angle,angleA=0,angleB=-90,rad=10"))
ax.annotate(
    'angle,\nshrink',
    xy=(4., 1), xycoords='data',
    xytext=(-60, 30), textcoords='offset points',
    bbox=dict(boxstyle="round", fc="0.8"),
    arrowprops=dict(arrowstyle="->",
                    shrinkA=0, shrinkB=10,
                    connectionstyle="angle,angleA=0,angleB=90,rad=10"))
# You can pass an empty string to get only annotation arrows rendered
ax.annotate('', xy=(4., 1.), xycoords='data',
            xytext=(4.5, -1), textcoords='data',
            arrowprops=dict(arrowstyle="<->",
                            connectionstyle="bar",
                            ec="k",
                            shrinkA=5, shrinkB=5))

ax.set(xlim=(-1, 5), ylim=(-4, 3))
```



We'll create another figure so that it doesn't get too cluttered

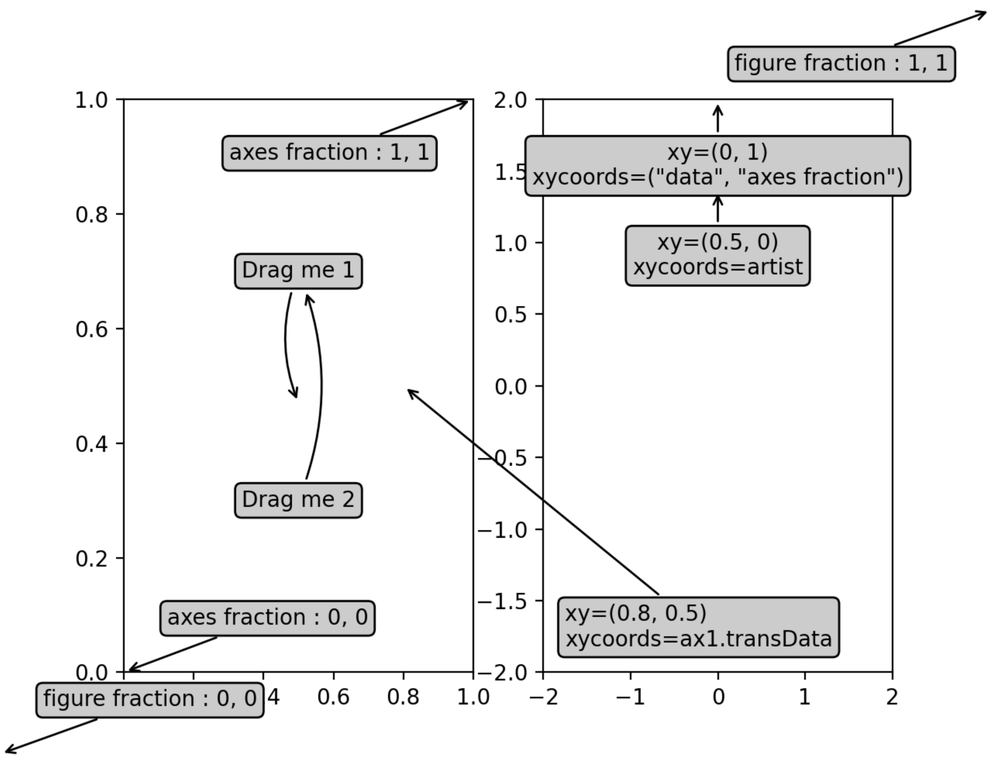
```
fig, ax = plt.subplots()

el = Ellipse((2, -1), 0.5, 0.5)
ax.add_patch(el)

ax.annotate('$->$',
            xy=(2., -1), xycoords='data',
            xytext=(-150, -140), textcoords='offset points',
            bbox=dict(boxstyle="round", fc="0.8"),
            arrowprops=dict(arrowstyle="->",
                            patchB=el,
                            connectionstyle="angle,angleA=90,angleB=0,rad=10"))
ax.annotate('arrow\nfancy',
            xy=(2., -1), xycoords='data',
            xytext=(-100, 60), textcoords='offset points',
            size=20,
            arrowprops=dict(arrowstyle="fancy",
                            fc="0.6", ec="none",
                            patchB=el,
                            connectionstyle="angle3,angleA=0,angleB=-90"))
ax.annotate('arrow\nsimple',
            xy=(2., -1), xycoords='data',
            xytext=(100, 60), textcoords='offset points',
            size=20,
            arrowprops=dict(arrowstyle="simple",
                            fc="0.6", ec="none",
                            patchB=el,
                            connectionstyle="arc3,rad=0.3"))
ax.annotate('wedge',
            xy=(2., -1), xycoords='data',
            xytext=(-100, -100), textcoords='offset points',
            size=20,
            arrowprops=dict(arrowstyle="wedge,tail_width=0.7",
                            fc="0.6", ec="none",
                            patchB=el,
                            connectionstyle="arc3,rad=-0.3"))
ax.annotate('bubble,\ncontours',
            xy=(2., -1), xycoords='data',
            xytext=(0, -70), textcoords='offset points',
            size=20,
            bbox=dict(boxstyle="round",
                      fc=(1.0, 0.7, 0.7),
                      ec=(1., .5, .5)),
            arrowprops=dict(arrowstyle="wedge,tail_width=1.",
                            fc=(1.0, 0.7, 0.7), ec=(1., .5, .5),
                            patchA=None,
                            patchB=el,
                            relpos=(0.2, 0.8),
                            connectionstyle="arc3,rad=-0.1"))
ax.annotate('bubble',
            xy=(2., -1), xycoords='data',
            xytext=(55, 0), textcoords='offset points',
            size=20, va="center",
            bbox=dict(boxstyle="round", fc=(1.0, 0.7, 0.7), ec="none"),
            arrowprops=dict(arrowstyle="wedge,tail_width=1.",
                            fc=(1.0, 0.7, 0.7), ec="none",
                            patchA=None,
                            patchB=el,
                            relpos=(0.2, 0.5)))

ax.set(xlim=(-1, 5), ylim=(-5, 3))
```



More examples of coordinate systems

Below we'll show a few more examples of coordinate systems and how the location of annotations may be specified.

```
fig, (ax1, ax2) = plt.subplots(1, 2)

bbox_args = dict(boxstyle="round", fc="0.8")
arrow_args = dict(arrowstyle="->")

# Here we'll demonstrate the extents of the coordinate system and how
# we place annotating text.

ax1.annotate('figure fraction : 0, 0', xy=(0, 0), xycoords='figure fraction',
             xytext=(20, 20), textcoords='offset points',
             ha="left", va="bottom",
             bbox=bbox_args,
             arrowprops=arrow_args)

ax1.annotate('figure fraction : 1, 1', xy=(1, 1), xycoords='figure fraction',
             xytext=(-20, -20), textcoords='offset points',
             ha="right", va="top",
             bbox=bbox_args,
             arrowprops=arrow_args)

ax1.annotate('axes fraction : 0, 0', xy=(0, 0), xycoords='axes fraction',
             xytext=(20, 20), textcoords='offset points',
             ha="left", va="bottom",
             bbox=bbox_args,
             arrowprops=arrow_args)

ax1.annotate('axes fraction : 1, 1', xy=(1, 1), xycoords='axes fraction',
             xytext=(-20, -20), textcoords='offset points',
             ha="right", va="top",
             bbox=bbox_args,
             arrowprops=arrow_args)

# It is also possible to generate draggable annotations

an1 = ax1.annotate('Drag me 1', xy=(.5, .7), xycoords='data',
                   ha="center", va="center",
                   bbox=bbox_args)

an2 = ax1.annotate('Drag me 2', xy=(.5, .5), xycoords=an1,
                   xytext=(.5, .3), textcoords='axes fraction',
                   ha="center", va="center",
                   bbox=bbox_args,
                   arrowprops=dict(patchB=an1.get_bbox_patch(),
                                   connectionstyle="arc3,rad=0.2",
                                   **arrow_args))
an1.draggable()
an2.draggable()

an3 = ax1.annotate('', xy=(.5, .5), xycoords=an2,
                   xytext=(.5, .5), textcoords=an1,
                   ha="center", va="center",
                   bbox=bbox_args,
                   arrowprops=dict(patchA=an1.get_bbox_patch(),
                                   patchB=an2.get_bbox_patch(),
                                   connectionstyle="arc3,rad=0.2",
                                   **arrow_args))

# Finally we'll show off some more complex annotation and placement

text = ax2.annotate('xy=(0, 1)\nxycoords=("data", "axes fraction")',
                    xy=(0, 1), xycoords=("data", 'axes fraction'),
                    xytext=(0, -20), textcoords='offset points',
                    ha="center", va="top",
                    bbox=bbox_args,
                    arrowprops=arrow_args)

ax2.annotate('xy=(0.5, 0)\nxycoords=artist',
             xy=(0.5, 0.), xycoords=text,
             xytext=(0, -20), textcoords='offset points',
             ha="center", va="top",
             bbox=bbox_args,
             arrowprops=arrow_args)

ax2.annotate('xy=(0.8, 0.5)\nxycoords=ax1.transData',
             xy=(0.8, 0.5), xycoords=ax1.transData,
             xytext=(10, 10),
             textcoords=OffsetFrom(ax2.bbox, (0, 0), "points"),
             ha="left", va="bottom",
             bbox=bbox_args,
             arrowprops=arrow_args)

ax2.set(xlim=[-2, 2], ylim=[-2, 2])
plt.show()
```



Total running time of the script: (0 minutes 2.412 seconds)

Download Jupyter notebook: annotation_demo.ipynb

Download Python source code: annotation_demo.py

Download zipped: annotation_demo.zip

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