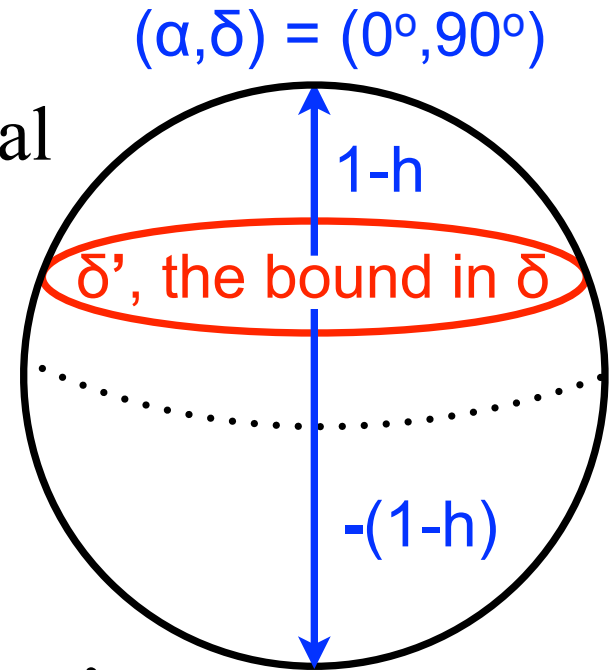


**Mangle**

# Intersections of multiple caps

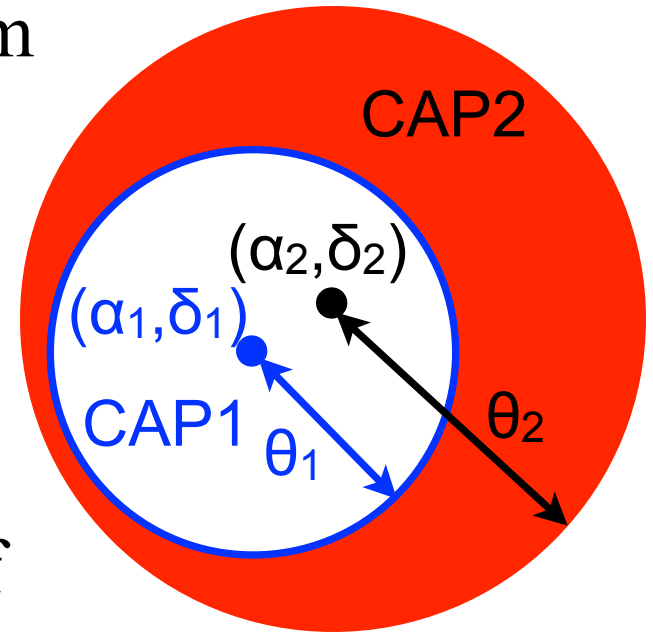
- By intersecting *multiple* spherical caps it is possible to construct general shapes on the surface of the sphere
- So, e.g., a “square” field bounded by  $(\alpha_{\min}', \alpha_{\max}', \delta_{\min}', \delta_{\max}')$  can be represented by the intersection of 4 spherical caps
- One cap bounded by  $\alpha_{\min}'$ , one by  $\alpha_{\max}'$  etc.
- But, for this sort of scheme, it is sometimes necessary to represent the sphere on the *other side of the cap*
- This is achieved simply in our convention by flipping the sign of  $(1-h)$  so that  $(x,y,z,(1-h)) \rightarrow (x,y,z,-(1-h))$



# Intersections of multiple caps - *Polygons*

---

- Consider the red area in the diagram
- It consists of **CAP1** and CAP2, but we want the intersection of everything that is *in* CAP2 with everything that is *not in* **CAP1**
- We can create everything that is *not in* **CAP1** by flipping the sign of the cap *constraint* (the cap size)
- So, if CAP2 is represented by  $(x_2, y_2, z_2, 1-h_2)$  and **CAP1** by  $(x_1, y_1, z_1, 1-h_1)$ , then the red area is represented by the intersection of  $(x_2, y_2, z_2, 1-h_2)$  and  $(x_1, y_1, z_1, -(1-h_1))$
- We will refer to shapes represented by the intersection of multiple caps as *polygons*



# Basic Python implementation of Mangle

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- Software called *Mangle* has been developed to apply the spherical cap formalism. The *astroconda* software stack has a basic Python implementation that can be imported with *import pymangle* (e.g. see the syllabus links)
    - *pip install pymangle*
  - Recall that *pip* is for managing Python package installations within a *conda* environment. i.e. your *conda* environment will have *pip* installed in it to manage Python packages for that one environment.
  - You can also install *astroconda* (see the syllabus links), which includes *pymangle*, but it is much slower.
-

# Basic Python implementation of Mangle

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- *Mangle* expects input files with caps combined into polygons in the following format:

```
1 polygons
polygon 1 ( 3 caps, 1 weight, 0 pixel, 0 str):
  -0.96592582629 0.25881904510 0 1
  0 0 1 0.41221474770752686
  0.209389006 0.781450409 0.587785253 0.00015230
```

- The first line states how many polygons are in the file note that `polygon(s)` and `cap(s)` are *always plural!*
  - In the second line, `caps` specifies how many caps are in the polygon and `str` lists the area of the polygon in steradians (which you can leave as `0 str` for now)
-

# Basic Python implementation of Mangle

---

- Note that if you wanted to create multiple polygons you could specify several blocks of caps, e.g.

2 polygons

```
polygon 1 ( 3 caps, 1 weight, 0 pixel, 0 str):  
  -0.96592582629 0.25881904510 0 1  
  0 0 1 0.41221474770752686  
  0.209389006 0.781450409 0.587785253 0.00015230  
polygon 2 ( 2 caps, 1 weight, 0 pixel, 0 str):  
  0.087155742747 -0.9961946980 0 1  
  0.785012134782 0.0686796625 0.615661475 1
```

- A collection of multiple polygons is typically referred to as a *mask* (or, occasionally, a *footprint*)
  - The `weight` allows polygons to be weighted differently when creating catalogs of random coordinates (a `weight=1` polygon would contain twice as many random points as a `weight=0.5` polygon)
-

# Python tasks

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*Please save all the plots you create as .png files in Git!*

1. Use your *circle\_cap* function from the previous lecture to create two caps, one of radius  $\theta=5^\circ$  centered at  $(\alpha, \delta) = (76^\circ, 36^\circ)$ , which I will call *cap 1* and one of radius  $\theta=5^\circ$  centered at  $(\alpha, \delta) = (75^\circ, 35^\circ)$ , which I will call *cap 2*
  2. Create a file containing these two caps as a single polygon in the *Mangle* format. The file should be called *intersection.ply*. Create a second *Mangle* file containing these two caps as two different polygons (i.e. polygon 1 should contain *cap 1* and polygon 2 should contain *cap 2*). This second file should be called *bothcaps.ply*
    - Note that the *Mangle* convention is to use an extension of *.ply* for files containing polygons
-

# Python tasks

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3. *import pymangle* and read in each of your masks, e.g.

- *minter = pymangle.Mangle("intersection.ply")*

then use *genrand* (see the syllabus link) to populate each mask with 10,000 random points. Plot the random points corresponding to each mask on a single plot with each mask's points plotted in a different color

- do you understand exactly how and why the masks are different? If not, then ask Jessie

4. Consider the file *intersection.ply* and its mask (*minter*)

- Flip the sign of the constraint on *cap 1* and read it in as a mask (*mflip1*)
  - Plot *minter* and *mflip1* on one plot in different colors
-



## Python tasks

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5. Now make the constraint on *cap 1* positive again, and instead flip the constraint on *cap 2*
    - Read in this new mask as *mflip2*
    - Plot *minter*, *mflip1* and *mflip2* in different colors on a single plot
    - Do you understand what happened when the caps' constraints became negative? If not, then ask Jessie
    - How would the plot you've just made compare to the mask in the file *bothcaps.ply*?
  6. Make *both* cap constraints in *intersection.ply* negative. Read in this mask and generate 1 *million* random points in it. This will take a suspiciously short amount of time.
    - Plot the random catalog. Does this mask make sense?
-