Initialization

psEquatorialToHorizontalCoordinates

psAstronomicalAngularSeparation

GW20170817

Background

blog post came out within days of the "event" (2017-08-23)
https://telescoper.wordpress.com/2017/08/23/ligo-leaks-and-ngc-4993/

a little later was this writeup in Nature (2017-08-25)
http://www.nature.com/news/rumours-swell-over-new-kind-of-gravitational-wave-sighting-1.22482

and even National Geographic (2017-08-25)
http://news.nationalgeographic.com/2017/08/new-gravitational-waves-neutron-stars-ligo-space-science/

There are rumors [above] around that LIGO/Virgo detected a gravity wave event and through whatever means it was determined exactly where it came from: NGC 4993 which is a very narby galaxy: 40 Mpc - $z = 0.009820$ at RA/dec $13^h\,9^m\,47.6^s$ / $-23.384°$. It is rumored to be a neutron star inspiral event.

It is also rumored that this might correspond to GRB 170817A (https://gcn.gsfc.nasa.gov/gcn3/21520.gcn3) with trigger time Thursday 2017-08-17 12:41:06.47 +00:00 . The best angular position of GRB 170817A is RA/dec $12^h\,47^m$ / $-39.8°$. This is $17.1084°$ from NGC 4993, however the 1σ statistical uncertainty in the GRB localization is $11.6°$ so GRB 170817A is consistent with NGC 4993. 2 s

Since the source is extremely close it could be very bright and even if it is far to the south it is still worth looking.

My calculations (below) indicate that NGC 4993 was (at Tianlai) $8.3°$ above the horizon at an azimuth $225.5°$ (to the southwest) At the time the Sun was $61.4°$ away at an altitude $1.77°$ and azimuth $287°$ (almost due west). Most likely the sun was behind the hills and had essentially set while (hopefully) NGC 4993 was still above the hills and about to set. If above the hills NGC 4993 would have directly illuminated the feeds on the cylinders (and the dishes if they were pointing straight up). The cylinder feeds are shielded on the sides so this may have blocked the source but I am not sure. The dish feeds are not shielded on the sides. If the dishes were pointed toward the NCP then it is possible the dish would have shadowed the feeds from NGC 4993 (I am not sure - it would have been $66.4°$ off axis).

This is a new type of event and we should not presuppose we know it's radio brightness. If for example it was as bright as Fast Radio Burst then since it is so close we might expect it's apparent brightness to be much larger than any seen so far. For example if a typical FRB at z=0.5 has peak flux density 1 Jansky we might expect this to have peak flux density 2.6 kJy, a thousand time brighter. Off axis (or even on axis) a 3 kJy source would be hard for detect if it is on for only a fraction of a second. However we shouldn't suppose we know the fluence. We can use the rapid time variation to separate it from other sources.

It was below the horizon for CHIME but nearly directly overhead for the HIRAX prototype - and certainly within the field of view of MWA.

This will not be the last of these types of events. It is rumored that LIGO/Virgo has seen several other events that look like neutron star inspirals but are below their (currently) very high significance standard for detection. These would be made public in the next data release which will presumably be sometime in October.

I think it is worth looking for with Tianlai - and this is good practice for incorporating pulsars into our beam calibration techniques.

Event

In[452]:=
```
$DateStringFormat = "ISODateTime";
```

In[453]:=
```
$datestringformat = {"DayName", " ", "Year", "-", "Month", "-", "Day", " ", "Hour",
   ":", "Minute", ":", "Second", ".", "Millisecond", " ", "ISOTimeZone"};
```

In[454]:=
```
$bursttime = DateObject[{2017, 08, 17, 12, 41, 04.45}, TimeZone → 0]
```

Out[454]= 2017-08-17T12:41:04 GMT

```
DateString[$bursttime, $datestringformat]
```

Thursday 2017-08-17 12:41:04.450 +00:00

In[455]:=
```
$hostgalaxy = "NGC4993";
```

```
GalaxyData[$hostgalaxy, image]
```

In[456]:=
```
{$RA, $declination} = {GalaxyData[$hostgalaxy, right ascension],
  Quantity[FromDMS[GalaxyData[$hostgalaxy, declination]], "AngularDegrees"]}
```

Out[456]= $\{13^h\, 9^m\, 47.6^s,\ -23.38388889°\}$

In[457]:=
```
$redshift = GalaxyData[$hostgalaxy, redshift]
```
Out[457]= 0.009820

In[458]:=
```
$distance = N[UnitConvert[(1 c)/(1 H0) GalaxyData["NGC4993", redshift], 1 Mpc]]
```
Out[458]= 40.8889 Mpc

GRB 170817A

In[501]:=
```
$GRBtime = DateObject[{2017, 08, 17, 12, 41, 06.47}, TimeZone → 0]
```
Out[501]= 2017-08-17T12:41:06 GMT

In[503]:=
```
UnitConvert[DateDifference[$bursttime, $GRBtime], "Seconds"]
```
Out[503]= 2.02 s

In[487]:=
```
{$RAGRB, $declinationGRB} = {12h 47m, -39.8`°}
```
Out[487]= {12h 47m, -39.8°}

In[488]:=
```
psAstronomicalAngularSeparation[{$RAGRB, $declinationGRB}, {$RA, $declination}]
```
Out[488]= 17.1084°

Tianlai

In[459]:=
```
Location["Hongliuxia Observatory"] =
  GeoPosition[{44.15433055555555`, 91.79716388888889}];
```

In[460]:=
```
timeZone["Hongliuxia Observatory"] = +8;
```

In[461]:=
```
$location = Location["Hongliuxia Observatory"];
```

In[462]:=
```
$timeZone = timeZone["Hongliuxia Observatory"]
```
Out[462]= 8

```
DateString[TimeZoneConvert[$bursttime, $timeZone], $datestringformat]
```
Thursday 2017-08-17 20:41:04.450 +08:00

In[463]:=
```
{$azimuth, $altitude} = psEquatorialToHorizontalCoordinates[
  {$RA, $declination}, GeoLocation → $location, Date → $bursttime]
```

Out[463]= {225.507°, 8.3077°}

In[464]:=
```
$sunPosition = SunPosition[$location, $bursttime, CelestialSystem → "Horizon"]
```

Out[464]= {286.84°, 1.77°}

In[465]:=
```
$siderealTime = SiderealTime[$location, $bursttime]
```

Out[465]= $16^h\ 30^m\ 51.2612^s$

```
$siderealTime - $RA
```

$3^h\ 21^m\ 3.6612^s$

```
psAstronomicalAngularSeparation[{$azimuth, $altitude}, $sunPosition]
```

61.3832°

Hartebeesthoek Radio Astronomy Observatory (HartRAO / HIRAX prototype)

In[466]:=
```
Location["Hartebeesthoek Radio Astronomy Observatory"] =
 GeoPosition[N[{-18641/720, 24917/900}]]
```

Out[466]= GeoPosition[{-25.8903, 27.6856}]

In[467]:=
```
timeZone["Hartebeesthoek Radio Astronomy Observatory"] =
   Africa/Johannesburg (time zone) ;
```

In[468]:=
```
$location = Location["Hartebeesthoek Radio Astronomy Observatory"];
```

In[469]:=
```
$timeZone = timeZone["Hartebeesthoek Radio Astronomy Observatory"];
```

```
DateString[TimeZoneConvert[$bursttime, $timeZone], $datestringformat]
```

Thursday 2017-08-17 14:41:04.450 +02:00

In[470]:=
```
{$azimuth, $altitude} = psEquatorialToHorizontalCoordinates[
  {$RA, $declination}, GeoLocation → $location, Date → $bursttime]
```

Out[470]= {81.69°, 77.1738°}

In[471]:=
```
$sunPosition = SunPosition[$location, $bursttime, CelestialSystem → "Horizon"]
```
Out[471]= {313.41°, 37.13°}

In[472]:=
```
$siderealTime = SiderealTime[$location, $bursttime]
```
Out[472]= $12^h\ 14^m\ 24.4752^s$

```
$siderealTime - $RA
```
$-1^h\ 5^m\ -23.1248^s$

Dominion Radio Astrophysical Observatory (DRAO)

49°19′16″N 119°37′26″W »
GeoPosition[{44 389 / 900, -215 323 / 1800}]

GeoPosition$\left[\left\{\frac{44389}{900}, -\frac{215323}{1800}\right\}\right]$

In[473]:=
```
Location["Dominion Radio Astrophysical Observatory"] =
  GeoPosition[N[{44389/900, -215323/1800}]]
```
Out[473]= GeoPosition[{49.3211, -119.624}]

In[474]:=
```
timeZone["Dominion Radio Astrophysical Observatory"] =
    America/Vancouver (time zone) ;
```

In[475]:=
```
$location = Location["Dominion Radio Astrophysical Observatory"];
```

In[476]:=
```
$timeZone = timeZone["Dominion Radio Astrophysical Observatory"];
```

```
DateString[TimeZoneConvert[$bursttime, $timeZone], $datestringformat]
```
Thursday 2017-08-17 04:41:04.450 -08:00

In[477]:=
```
{$azimuth, $altitude} = psEquatorialToHorizontalCoordinates[
   {$RA, $declination}, GeoLocation → $location, Date → $bursttime]
```
Out[477]= {36.5394°, -60.1356°}

In[478]:=
```
$sunPosition = SunPosition[$location, $bursttime, CelestialSystem → "Horizon"]
```
Out[478]= {65.67°, -2.94°}

In[479]:=
```
$siderealTime = SiderealTime[$location, $bursttime]
```

Out[479]= $2^{h}\ 25^{m}\ 10.2085^{s}$

```
$siderealTime - $RA
```

$-11^{h}\ 16^{m}\ -37.3915^{s}$

FRB

```
UnitConvert[1 Jy (0.5/$redshift)^2, "Kilojanskies"]
```

2.59242 kJy

Optical