Nithyanandan Thyagarajan (CSIRO)
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Short spacing with a scanning interferometer

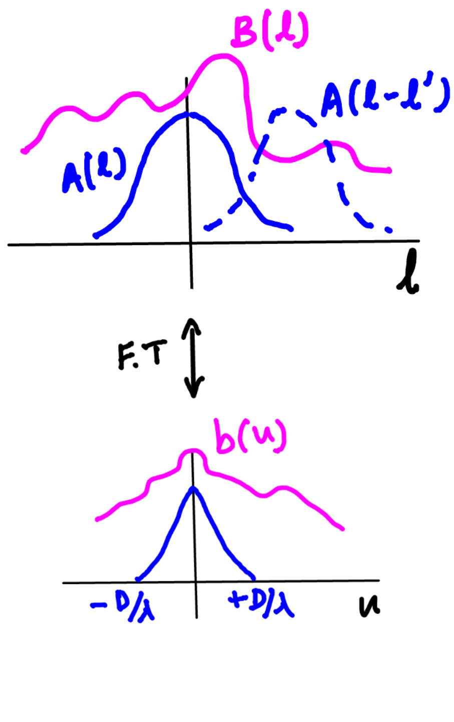
Motivation:

- Aperture synthesis typically does not measure short spacing information.
- Results in large negative bowls in the image
- Can affect spectral line studies as the size scale of these features change with frequency.

Part 1:
Visibility function with a single telescope via scanning

Part 2:
Short spacing visibilities via scanning with an interferometer

Visibility function with a single telescope via scanning



$B'(l) = B(l).A(l)$
is the apparent brightness

At a single instant, a single telescope measures

$\int B'(l)\,dl = \int B(l)A(l)\,dl$

In the aperture plane, this corresponds to sampling

$b'(u) = b(u) * a(u)$ at $u=0$

$b'(0) = \big(b(u) * a(u)\big).\delta(u)$

Nithyanandan.Thyagarajan@csiro.au

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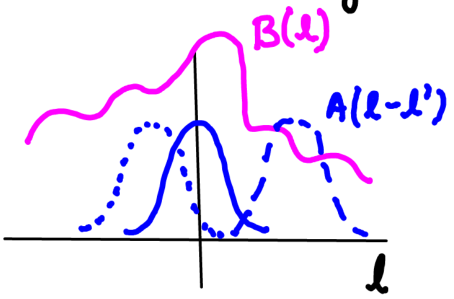
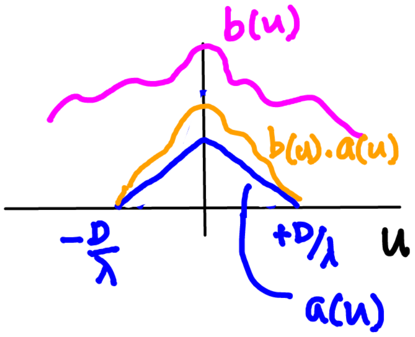
Repeat the process by scanning by letting the sky drift or shifting the beam to a different location.



The scanned function is sampled at different pixel locations on the sky

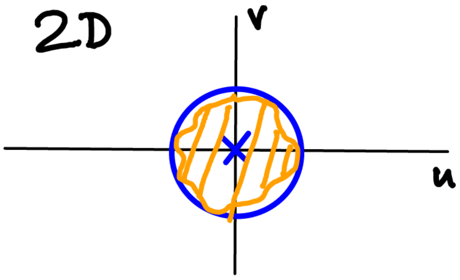
$$B''(l) = (B(l) * A(l)) . S(l)$$



When Fourier transformed it yields the function

$$b''(u) = b(u) . a(u)$$

2D



By scanning with a single telescope, we can measure Visibilities within the dish diameter.

This is not a direct measurement by is contained in the scanned pixels which can be obtained using a Fourier transform.

Where did this new information appear from?

- The new structural information in the scanned samples and their relative locations provide additional phase and amplitude information into the neighbouring uv besides the zero spacing.
- Other interpretations?

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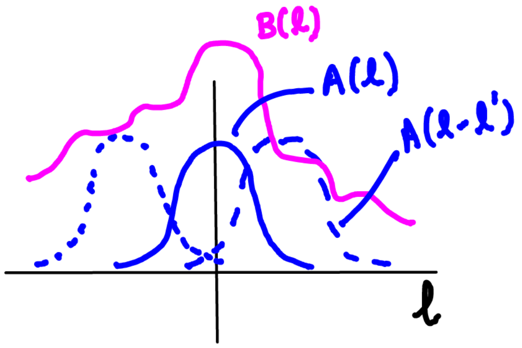
Short spacing visibilites with scanning interferometer



Consider a general case with inteferometer spacing $u=u_0$ phase center at $l=0$, and the pointing center at $l=l'$

Measurement equation is

$$b''(u) = \int B(l)A(l-l')\, e^{+i2\pi u_0 l}\, dl$$

$$= \left\{ b(u) * \left[a(u)\, e^{-i2\pi u l'}\right] \right\} \delta(u-u_0)$$

$$= \left\{ \int b(u'-u)\, a(u)\, e^{-i2\pi u l'}\, du \right\} \delta(u-u_0)$$

$$= \int \underbrace{b(u_0-u)}_{\text{shift to } u_0}\, \underbrace{a(u)}_{\uparrow\ \text{aperture illumination}}\, \underbrace{e^{-i2\pi u l'}}_{\text{phase ramp depends on } l'}\, du$$

$$= \left\{ \left(B(-l)\, e^{-i2\pi u_0 l}\right) * A(l) \right\} \delta(l-l')$$

By creating multiple samples of $b''(u)$ by scanning at various values of l' by the interferometer, it can be Fourier transformed to obtain the visibility function $b(u_0-u)\,a(u)$

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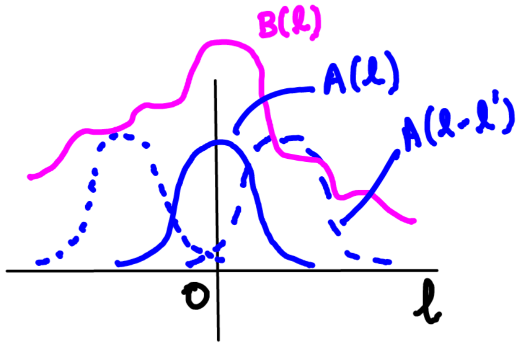
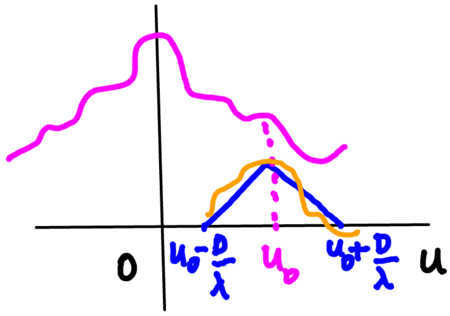
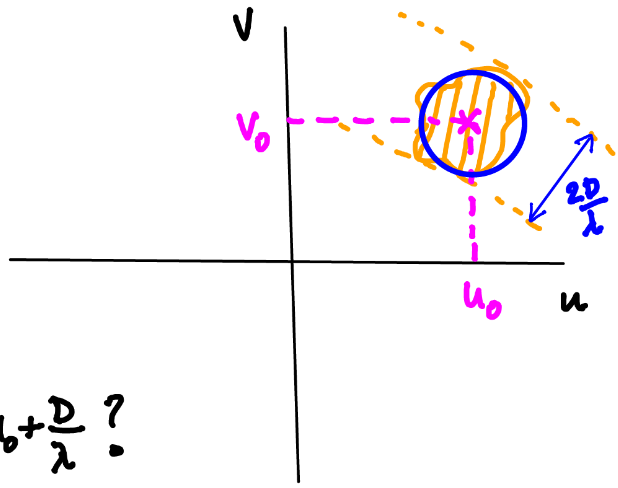


F.T
$\longleftrightarrow$



- How to visualize where the additional information from the mosaicking comes into the aperture plane?



- What is the short spacing gained here? $u_0-\frac{D}{\lambda}$ to $u_0+\frac{D}{\lambda}$?

We obtain visibilities as a function of scan position.

$$V(u_0, l') = \int B(l)\,A(l-l')\,e^{-i2\pi u_0 l}\,dl$$

$$= \left\{\left(B(-l)\,e^{-i2\pi u_0 l}\right) * A(l)\right\} \cdot \delta(l-l')$$

The final visibilities are obtained as a FT of $V(u_0, l')$

$$V'(u_0, \Delta u) = \int V(u_0, l')\,e^{-i2\pi \Delta u\, l'}\,dl'$$

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