



FIG. 1: (a) The two detectors, A and B, are used to observe the star Sirius. First choosing the best θ for the observation, and then measuring the correlations as a function of d , HB&T determined $2\delta\theta$ - the angular width of Sirius. (b) The resulting correlation graph. Can you reproduce it?

Allotted time: 2 hours

CPL- first spring challenge

Hanbury-Brown - Twiss and Sirius

When two light receivers are used to monitor the light of a far away source, Hanbury-Brown and Twiss showed that if there is a phase difference ϕ for light arriving at the two receivers then the product of the observed signals is:

$$C_{AB} = \langle I_A I_B \rangle = \frac{I_{A0} I_{B0}}{4} \left(1 + \frac{1}{2} \cos \phi \right) \quad (1)$$

where the brackets indicate time averaging, and the individual intensities observed in the detectors A and B are: $I_A(t) = I_{A0} \cos^2(\omega t)$ and $I_B(t) = I_{B0} \cos^2(\omega t + \phi)$.

In their experiment, HB&T trained their detectors on Sirius and measured the correlation $C_{AB}(d)$ as a function of distance between the detectors d (see figure). After much interpretation, we deduce that the graph given actually plots the result for

$$\Gamma(d) = \frac{C_{AB}(d) - I_{A0} I_{B0}/4}{C_{AB}(0) - I_{A0} I_{B0}/4}, \quad (2)$$

which is the reduced correlation between the two detectors, normalized by the maximum correlations (when they are right next to each other).

If the star is covering the angular range $\theta - \delta\theta \rightarrow \theta + \delta\theta$:

1. What is the range of phase differences ϕ that will be observed in the detectors with separation distance d ? Assume that the relevant wavelength is the Sirius black-body maximum corresponding to $T = 10500K$.
2. What is the ideal θ to use for the experiment in order to achieve maximal resolution of $\delta\theta$?
3. Assume that θ is chosen to afford maximum resolution. Make a reasonable model for how the star's image profile translates to a distribution of ϕ at a given d , and use it to calculate $\Gamma(d; \delta\theta)$.

Plot the result which matches best with the given plot in the figure. What is the deduced $\delta\theta$ of Sirius?

Comments: feel free to use notes, constant tables, or tidbits of information from the web.