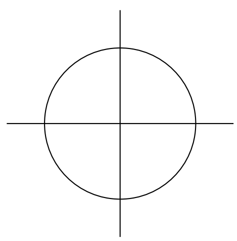
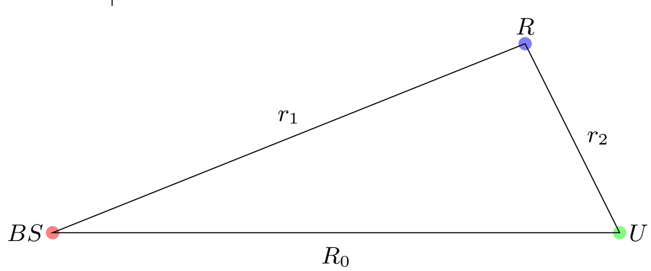
$$r_{11} = -r\cos(\theta-\alpha) + \sqrt{R_1^2 - r^2\sin^2(\theta-\alpha)}$$

$$r_{12} = R_1\cos\alpha - r\cos(\theta-\alpha) + \sqrt{[R_1\cos\alpha - r\cos(\theta-\alpha)]^2 - r^2\sin^2\theta - [R_1 - r\cos\theta]^2 + R_2^2}$$

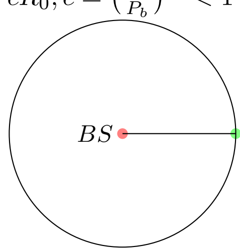
$$\begin{aligned}\rho(r,\theta) &= \int_{-\alpha_2}^{\alpha_1} f_\alpha(\alpha)\int_{r_{11}}^{\infty} f_l(l)\,dl\,d\alpha + \int_{\alpha_1}^{2\pi-\alpha_2} f_\alpha(\alpha)\int_{r_{12}}^{\infty} f_l(l)\,dl\,d\alpha \\ &= \int_{-\alpha_2}^{\alpha_1}\frac{1}{2\pi}e^{-\lambda\pi r_{11}^2}\,d\alpha + \int_{\alpha_1}^{2\pi-\alpha_2}\frac{1}{2\pi}e^{-\lambda\pi r_{12}^2}\,d\alpha\end{aligned}$$

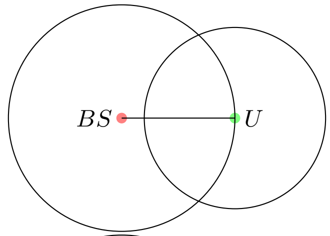


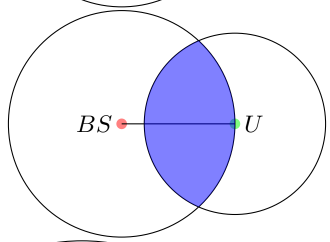


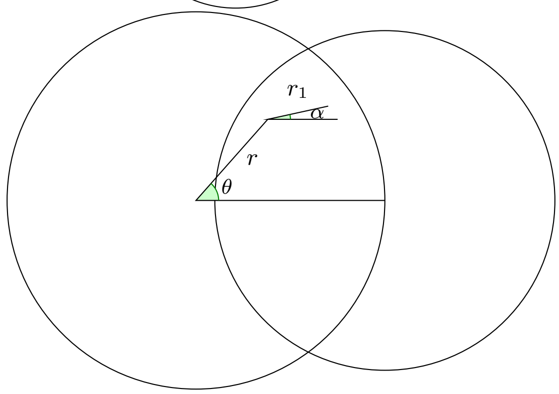
$$\text{policy:}\{P^b r_1^{-\alpha} < P_b R_0^{-\alpha}, P_r r_2^{-\alpha} > P_b R_0^{-\alpha}\}$$
$$\{r_1 < R_0, r_2 < R_2\}$$

where $R_2 = cR_0, c = \left(\frac{P_a}{P_b}\right)^{\frac{1}{\alpha}} < 1$









$$a^2 = r^2 + r_1^2 - 2r_1 r\cos(180 - \theta + \alpha)$$
$$b^2 = (r_1 \sin\alpha + r\sin\theta)^2 + (R_0 - r\cos\theta - r_1 cos\alpha)^2$$

$$a^2 > R_0^2 \Rightarrow r_1 > r_{11}$$
$$b^2 > R_2^2 \Rightarrow r_1 > r_{12}$$

$$\beta_1 = \cos^{-1}\left(1 - \frac{R_2^2}{2R_0^2}\right) - \theta$$
$$\beta_2 = \cos^{-1}\left(1 - \frac{R_2^2}{2R_0^2}\right)$$
$$\alpha_1 = \theta + \tan^{-1}\left(\frac{R_0\sin\beta_1}{R_0\cos\beta_1 - r}\right)$$
$$\alpha_2 = \tan^{-1}\left(\frac{r\sin\theta + R_0\sin\beta_2}{R_0 cos\beta_2 - r\cos\theta}\right)$$

$$P = \begin{pmatrix} Q & R \\ \mathbf{0} & I_r \end{pmatrix}$$

$$
\begin{aligned}
N &= \sum_{k=0}^{\infty} Q^k = (I - Q)^{-1} \\
Expected &= \mathbf{t} = N\mathbf{1} \\
variance &= (2N - I)\mathbf{t} - \mathbf{t}_{sq}
\end{aligned}
$$