Improving **Null Depth** Measurement with **statistics** : theory and first results with the Palomar Fiber Nuller

Charles Hanot

ARC meeting, 11 February 2010
What is the Null Depth?

\[ ND = \frac{I_{min} - Bkg}{I_{max} - Bkg} \]
Problem: How to measure Null Depths?

\[ ND = \frac{I_{min} - Bkg}{I_{max} - Bkg} \]
Problem: How to measure Null Depths?

Tipton Sweep, null = 0.0391

- Mean?
- Median??
- How??
Classical method

• Non-calibrated ND

\[ \langle N(t) \rangle = N_a + \langle N_{Instr}(t) \rangle \]

\[ \langle N_{cal}(t) \rangle = N_{a,cal} + \langle N_{Instr}(t) \rangle \]

• Calibrated ND

\[ N_a = \langle N(t) \rangle - \langle N_{cal}(t) \rangle + N_{a,cal} \]
Classical method

Advantages
• Easy to process
• Used for centuries

Drawbacks
• Duty cycle
• Require lots of observations
• Limited by fluctuations
• $N_{a,\text{cal}}$ dependent
Statistical Method

\[ N(t) = I_N(t)\left( \frac{\Delta \phi_d(t)^2}{4} + \frac{\delta I(t)^2}{16} + \alpha_{rot}^2 \right) + N_a \]

- Normalized intensity
- Phase error
- Intensity mismatch
- Polarization
- Astrophysical leakage
\[ N(t) = I_N(t) \left( \frac{\Delta \phi_d(t)^2}{4} + \frac{\delta I(t)^2}{16} + \alpha_{rot}^2 \right) + N_\alpha \]
Statistical Method

\[ N(t) = I_N(t)\left(\frac{\Delta \phi_d(t)^2}{4} + \frac{\delta I(t)^2}{16} + \alpha_{rot}^2\right) + N_a \]

If:
• Random fluctuations are Normal distribution
• Random fluctuations are uncorrelated

Then:
• \( N(t) \) has an analytical expression
Statistical Method

- $N_a = 1 \times 10^{-3}$
- Phase = 0.2 rad
- $\delta I = 2.37\%$
Palomar Fiber Nuller
Comparison classical vs statistical

Alpha Boo

Alpha Her

jeudi 11 février 2010
Results

- ND excess : $0.6 \times 10^{-3}$
- Symmetric
- Constrain the model
Results

• ND excess : $4.7 \times 10^{-4}$
• Theo. excess : $3.5 \times 10^{-4}$
• Bias : $1.2 \times 10^{-4}$
Conclusion

• A new data reduction method for interferometry
• Better stability and accuracy of the measurements
• Better sensitivity
• Best ND ever achieved on the sky