

Last year and this talk:

## Quantum Fluctuation Dissipation Theorems

University of Oxford (MMathPhys)

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Joseph S Smith, BUSSTEPP 2018

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Next Year:

## Theory Beyond the Standard Model

University of Cambridge (PhD)

# The Take Home Message

**Fluctuation-Dissipation theorems are everywhere  
(even in particle physics)**

# The question

*What on earth is a Flucutation-Dissipation theorem?*

• 1900

• 1905: sutherland and Einstein

fluctuation

$\propto$

$$D = \frac{k_B T}{\gamma}$$

$\gamma \rightarrow$  Dissipation



1927

Heisenberg  
Principle

uncertainty



1930

• 1950

• 1951 Callen & Welton:  
The QFT

$$\underbrace{(G_{FF}(\omega) - G_{FF}(-\omega))}_{\text{Dissipation}} \cosh\left(\frac{\beta\omega}{2}\right) = \underbrace{G_{FF}(\omega) + G_{FF}(-\omega)}_{\text{Fluctuation}}$$

• 1966 Kubo

Linear response  
theory

↙  
"The fluctuation-dissipation  
theorem"

• 1970



1974 Hawking Radiation.



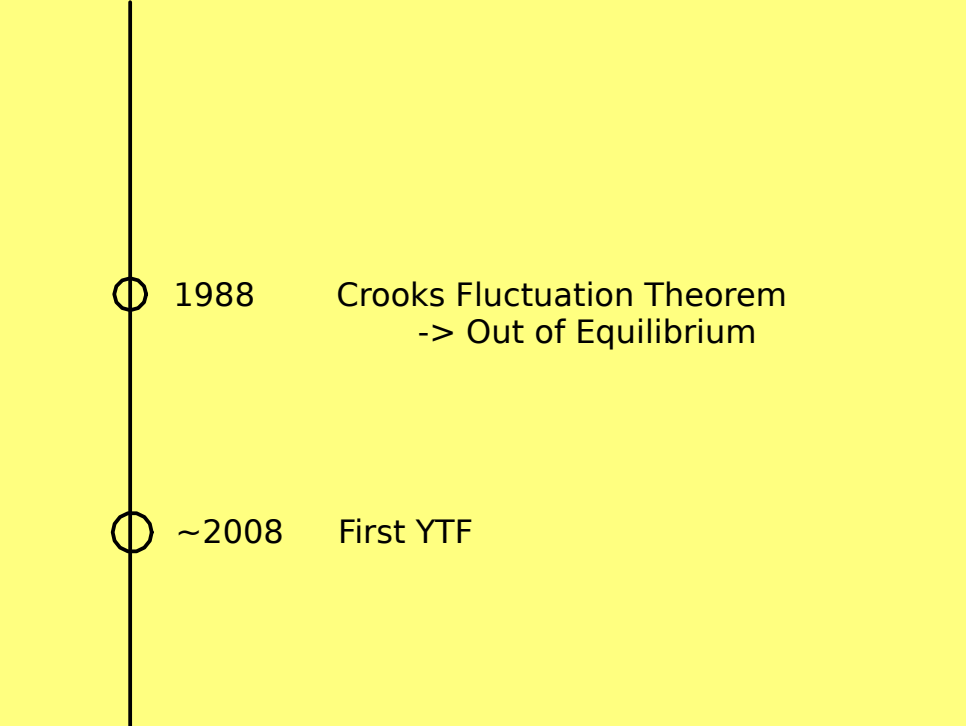
1975 First Personal Computers



○ 1980

○ 1985

Mottola  
QFDT's and Inflation



○ 1988 Crooks Fluctuation Theorem  
-> Out of Equilibrium

○ ~2008 First YTF



2018

Giataaganas, Lee and Yeh  
Fluctuation and Dissipation  
in Holographic Theories



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