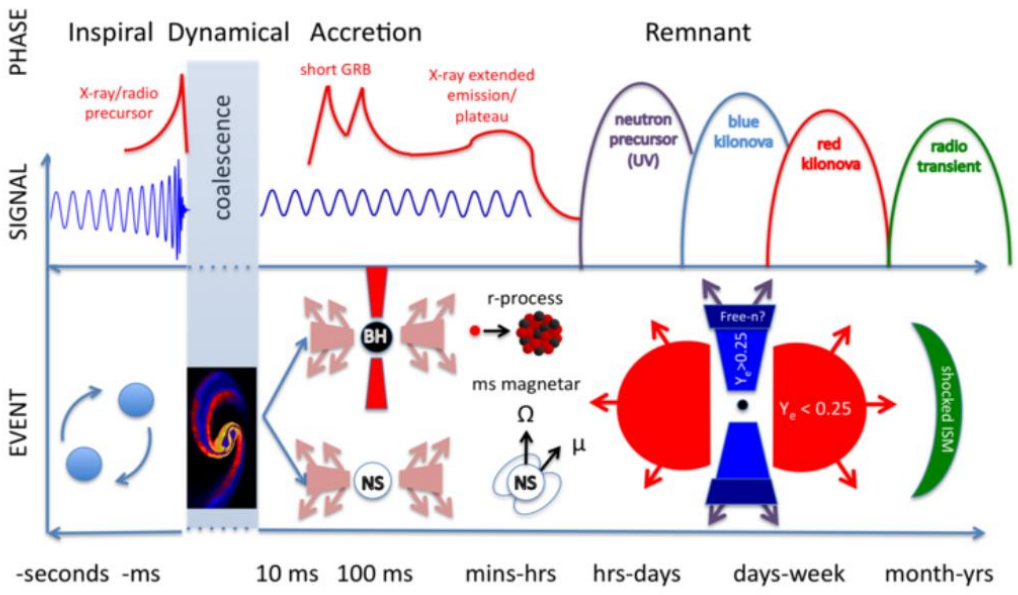
Theory: T10

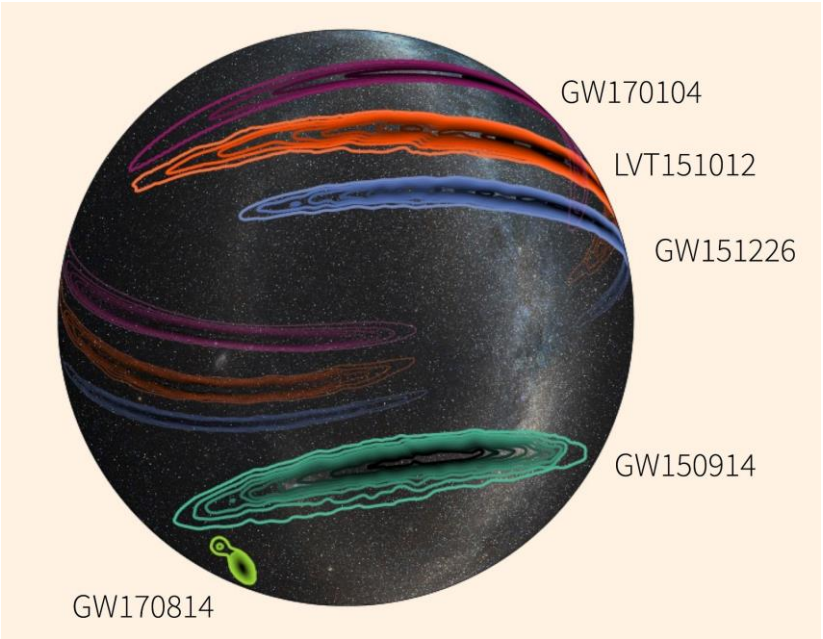
"Gravitational-wave Optical Transient Observer (GOTO)"

IBM, Wednesday Nov 15th, 2017

Introduction & Motivation

- **The first direct detection of Gravitational Wave (GW):** opens a "**new window**" for studying the cosmos
  - GW **optical/EM counter-part** follow-up observations are desirable, i.e. GW170814 (NS-NS merger)
  - Need a **fast response and deep photometry** to catch an unknown, if any, optical signal after a GW trigger





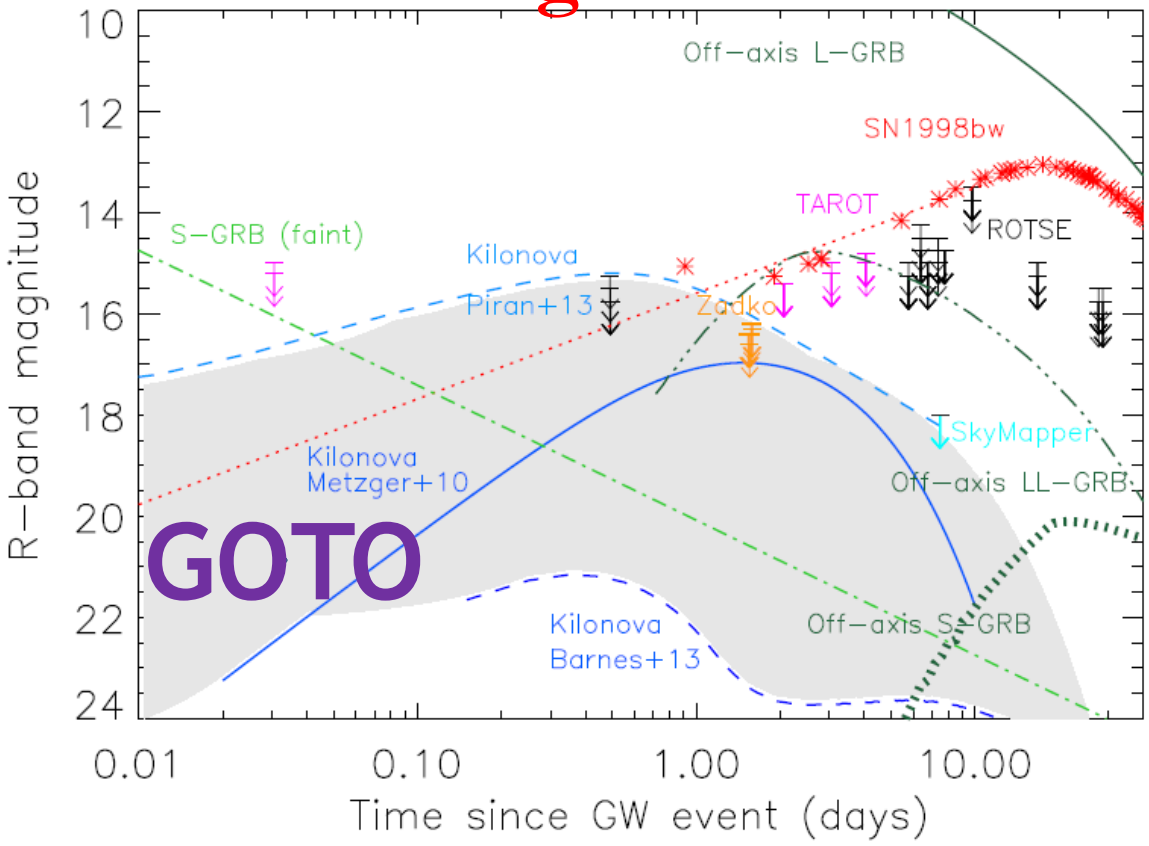
Introduction & Motivation

Gravitational-wave Optical and Transient Observer (GOTO) is one such effort

GOTO
GRAVITATIONAL-WAVE OPTICAL TRANSIENT OBSERVER

- University of Warwick
- Monash University
- Armagh Observatory
- University of Sheffield
- University of Leicester
- NARIT

Searching fast and wide



Objectives

- Practical problem in designing instruments and optical follow-up survey to get the desired **survey speed & depth**

- **Information given**
  - Telescope aperture, f-ratio
  - Typical seeing @ the telescope site
  - CCD properties (Gain, RON, DN, pixel size)
  - Survey speed, magnitude limit

Knowledge & Skill

- Knowledge: Instrumentation & Observational
  - Telescope and basic optics
  - CCD photometry
  - Signal-to-Noise ratio calculation
  - Experiment design, exposure time calculation

- Skills
  - Trigonometry
  - Approximation and numerical method
  - Solving quadratic equations

Tasks (20 marks total)

- a) (6 marks) Calculate plate scale at the focal plane (required later for part b))

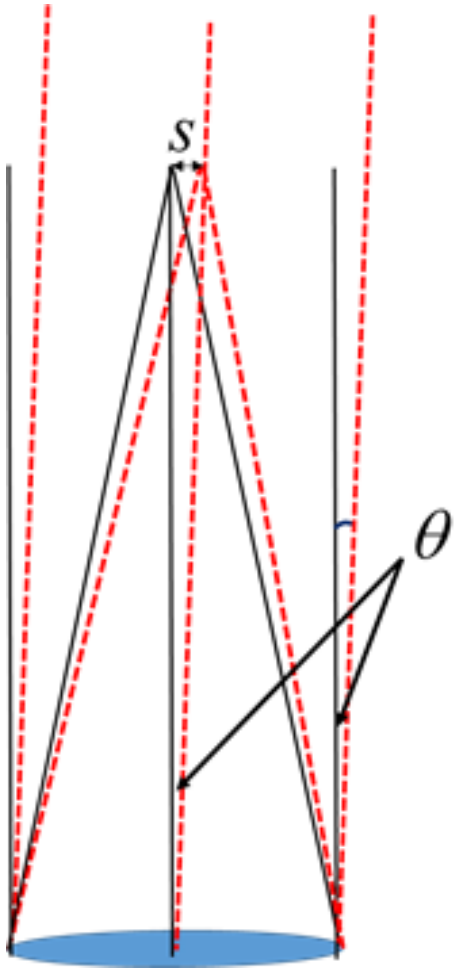
$$\tan\theta = \frac{S}{f}, \quad \tan\theta \approx \theta$$

where f is the focal length

Plate Scale

$$\frac{\theta}{S} = \frac{1}{f}$$

$$f = \text{F-ratio} \times \text{Diameter}$$



- b) (6 marks) Calculate exposure time to reach 21 mag @ SNR=5, for RON & DN dominated case

$$t = \frac{25\,\mathrm{DN} + \sqrt{(25\,\mathrm{DN})^2 + 100\,\mathrm{CR}^2\mathrm{RON}^2}}{2\,\mathrm{CR}^2} = 521\ \mathrm{s} = 8.68\ \mathrm{minutes}$$

Tasks

- c) (4 marks) Calculate more realistic exposure time to reach 21 mag @ SNR=5, when we include Poisson noise from the source count

$$\mathrm{SNR} = \frac{\mathrm{CR} \times t}{\sqrt{\mathrm{RON}^2 + (\mathrm{DN} \times t) + \mathrm{CR} \times t}},$$

$$\mathrm{SNR} \propto t^{\frac{1}{2}}$$

$$t = \frac{25(\mathrm{DN}+\mathrm{CR}) + \sqrt{25^2(\mathrm{DN}+\mathrm{CR})^2 + 100\mathrm{CR}^2\mathrm{RON}^2}}{2\mathrm{CR}^2} = 666 \text{ s} = 11.1 \text{ minutes}$$

- d) (4 marks) Calculate the required CCD side length (size)
  - Putting the concept of FoV, survey depth and speed together

Phuket, Thailand 2017

Thank You