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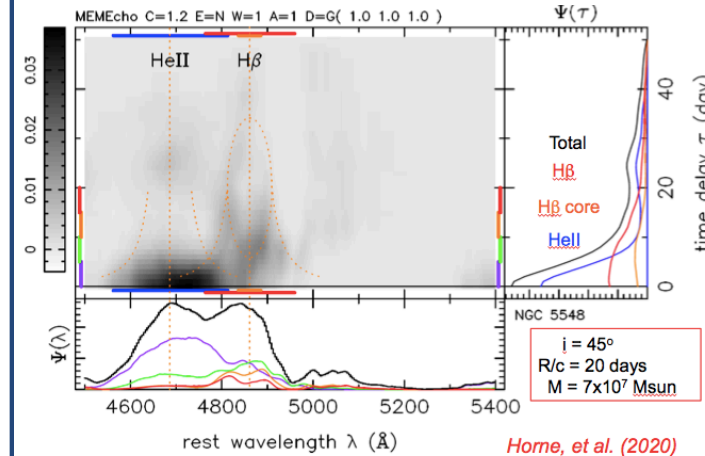
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Abstract MEMEcho is a Maximum Entropy Mapping code that fits an echo model to quasar lightcurves. It models observed spectral variations, in lines and/or continuum, as delayed responses to short-wavelength (X-ray, UV) variations, deriving 1D delay maps $P(\tau)$ and velocity-delay maps $P(v, \tau)$. The light travel time delay τ measures the size and the delay maps probe the radial structure of the continuum and emission-line regions in quasars. **MEME (Maximum Entropy Modelling of Epidemics)** uses MEMEcho to model the COVID-19 epidemic, fitting reported deaths as a delayed response to reported cases. Results for many nations are posted daily at <http://star-www.st-and.ac.uk/~kdh1/pub/covid19/covid19.html>

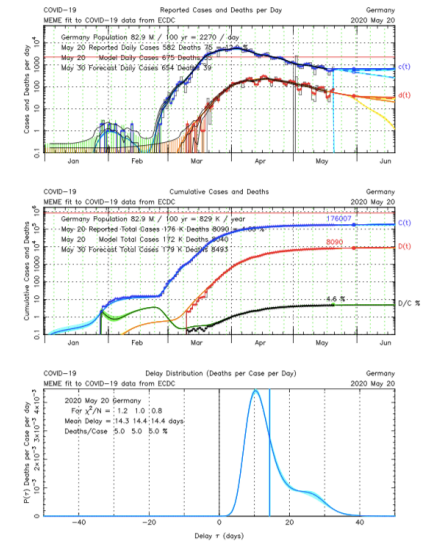
Project Description

Quasar variations in X-ray and UV, recorded by Swift and HST, combined with optical monitoring using ground-based robotic telescopes (e.g. the three 1m SUPAscopes in the Las Cumbres Observatory (LCO) global telescope network) are recording quasar variations with unprecedented time sampling and signal-to-noise ratio. This enables use of light travel time and wavelength (Doppler shift) to recover 2-D maps of the accretion disc and emission-line regions. Velocity-delay maps give the black hole mass and the structure of the flow that feeds the black hole to power the quasar. Since 26 Mar, the MEMEcho code developed for quasar lightcurves is being applied to the COVID-19 epidemic, modelling the history of reported deaths $d(t)$ as a delayed response to reported cases $c(t)$, with a delay map $P(\tau)$.

MEMEcho velocity-delay map of HeII and H β in NGC 5548



MEME fit for Germany



MEMEcho – Maximum Entropy Echo Mapping of Quasars

- MEMEcho fits quasar lightcurves to probe the micro-arcsecond structure of their accretion discs and photo-ionised emission-line regions.
- In NGC 5548, velocity-delay maps $P(v, \tau)$ show that the emission-line region is a Keplerian disc extending from 2 to 20 light days, inclined by 45 degrees, with an outer rim 20 light days from the $7 \times 10^7 M_{\text{sun}}$ black hole.

MEME – Maximum Entropy Modelling of Epidemics

- MEMEcho fits deaths $d(t)$ as delayed responses to cases $c(t)$.
- The delay map $P(\tau)$, defining the mean delay and the case fatality rate, varies markedly from country to country.

MEME web page:

<http://star-www.st-and.ac.uk/~kdh1/pub/covid19/covid19.html>