Looking beyond 30m-class telescopes: WLTs and the Colossus Project
Currently planned WLTs use technologies extrapolated from Keck – we can beat this curve only by changing basic WLT telescope assumptions.
There are compelling new questions that are best-solved with a different kind of telescope.

Under some conditions its likely we can beat the cost and mass scaling correlations that seem to regulate the multi-function WLTs now in construction.
...perhaps 25% of late-type stars have HZ planets, observing them is a dynamic range problem
Scattered and emitted exoplanet-to-star brightness ratio – a contrast problem

Flux contrast for a planet in the habitable zone versus star temperature in scattered stellar light (blue), in planet emission at a wavelength of 5μm (green) and in emission at 10μm (red). Solid lines show contrast of Earth-radius planets and dashed lines correspond to 5 Earth-radius planets. The Earth-like geometrical albedo 0.3 was assumed.
What could we see on an alien planet. Rotational light modulation and surface structure
The Earth from space

Visible light variability
NASA Earth Observatory Data: 10C thermal perturbation around cities

Temp: 0-36°C
Life Biomarkers: Distinguishing natural variability

5μ timeseries photometry

10μ timeseries photometry
Exoplanetary-scale heat
\[ \Omega(t) = \frac{P}{P_{\text{star}}} \]
How many exoplanets could we see with bigger telescopes and good coronagraphs?

Maximum number of detectable Earth-size HZ planets (assuming 1 per star and $\Omega\approx1$) versus telescope size. 'Star' symbols show number detectable at 5μm due to thermal emission assuming $5\times10^{-8}$ contrast at an angle of $2\lambda/D$ from the host star and at 500nm with five times smaller contrast at $20\lambda/D$. 'Diamond' symbols show detectable number with corresponding IR contrast at $2\times10^{-8}$ and ‘plus’ symbols show number at $10^{-8}$. Up arrow shows the increase in detection numbers if HZ planets have a radius twice the Earth’s.
Colossus Optical Configuration
60 x 8m phased-array OAP telescopes

M1: ≈60 x 8 off-axis parabolas
M1 - R=40m parabola
Image F/5
f = 380m
M2: 60 x 38cm
Encoding mirror phase in the psf

One mirror phase change $\pi/2$

0.01 arcsec
Image domain mirror phase recovery

PSF from 59 random mirror phases

8m Airy diffraction ring
Minimizing mirror mass

\[ z_{pp} = \frac{10a^4}{Et^2} \]

a, t in cm, E in Pa, \( \rho \) cgs

Borosilicate...

\( Z = 25 \text{nm}, a=20 \text{cm}, t=5 \text{cm} \)

\[ t^2 = m\sqrt{10\rho/EZ} \]

\( m=100 \text{g} \rightarrow t=1 \text{cm} \text{ with } a=10 \text{cm} \)

\( D=8 \text{m} \rightarrow 5000 \text{ actuators} \)

Area mass density 500kg/m\(^2\) \( \rightarrow \) 60kg/m\(^2\)
WLT mass scaling and Colossus
• Redundant baseline phased array
• Narrow FOV (8”), $m_V < 13$
• Image domain subaperture phase reconst.
• “Live mirror” lightweighting achieves 50kg/m²
• Nulling coronagraphy

www.the-colossus.com