實作專題
超快光電儀器

Shang-Da Yang 楊尚達
Ultrafast Photonics Laboratory
超快光電實驗室

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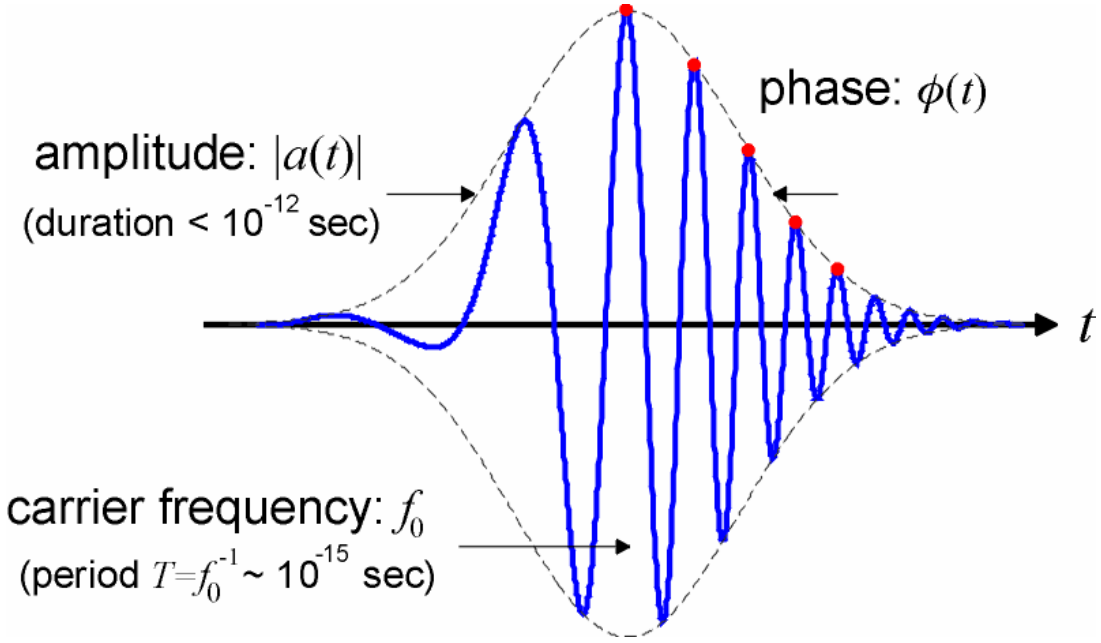
什麼是超快光學(ultrafast optics)？

All EM waves have the same speed: $c = 1/\sqrt{\mu_0 \varepsilon_0} = 3\times10^8\ (\mathrm{m/sec})$

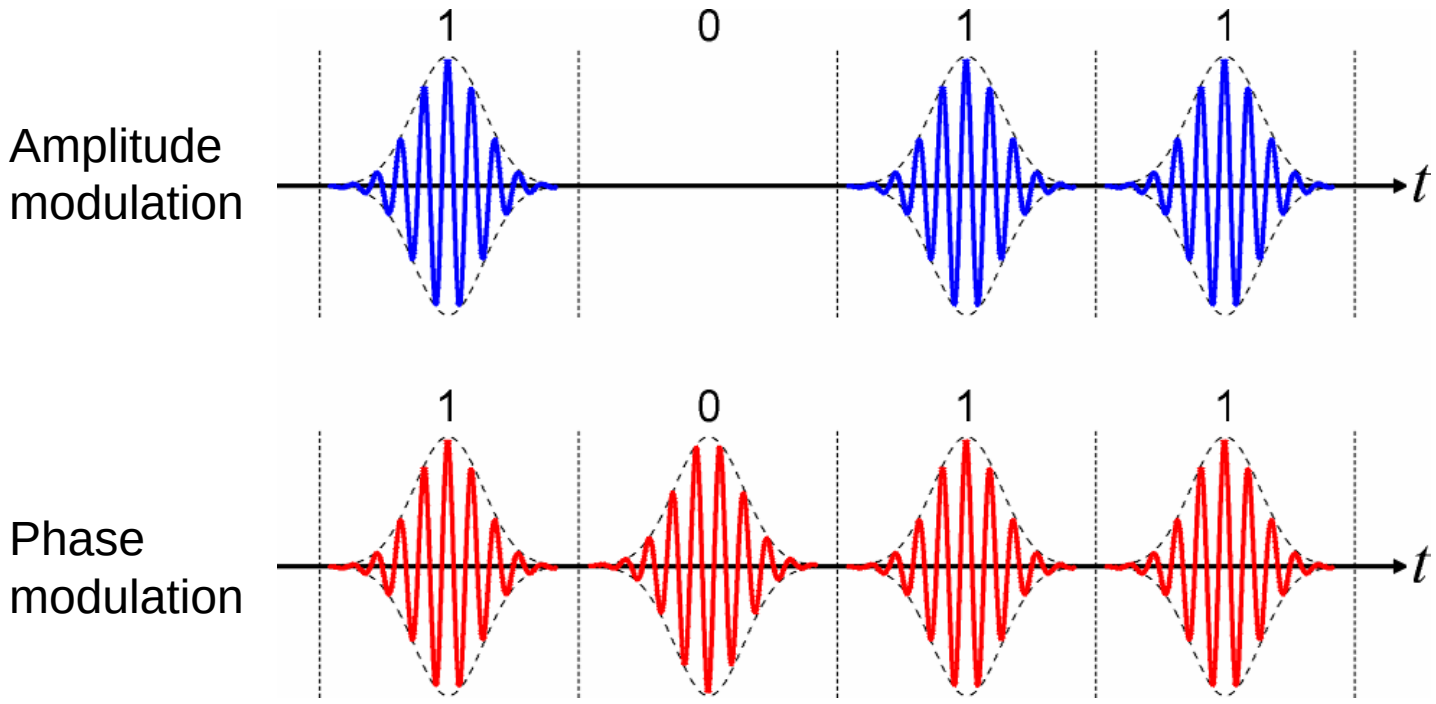
$\Rightarrow$ How can light be “fast” or “slow”?



$$e(t) = |a(t)|\cos[2\pi f_0 t + \phi(t)]$$

Ultrafast is defined by the pulse width, not by the light speed

超短光脈衝的應用–超大頻寬光通訊



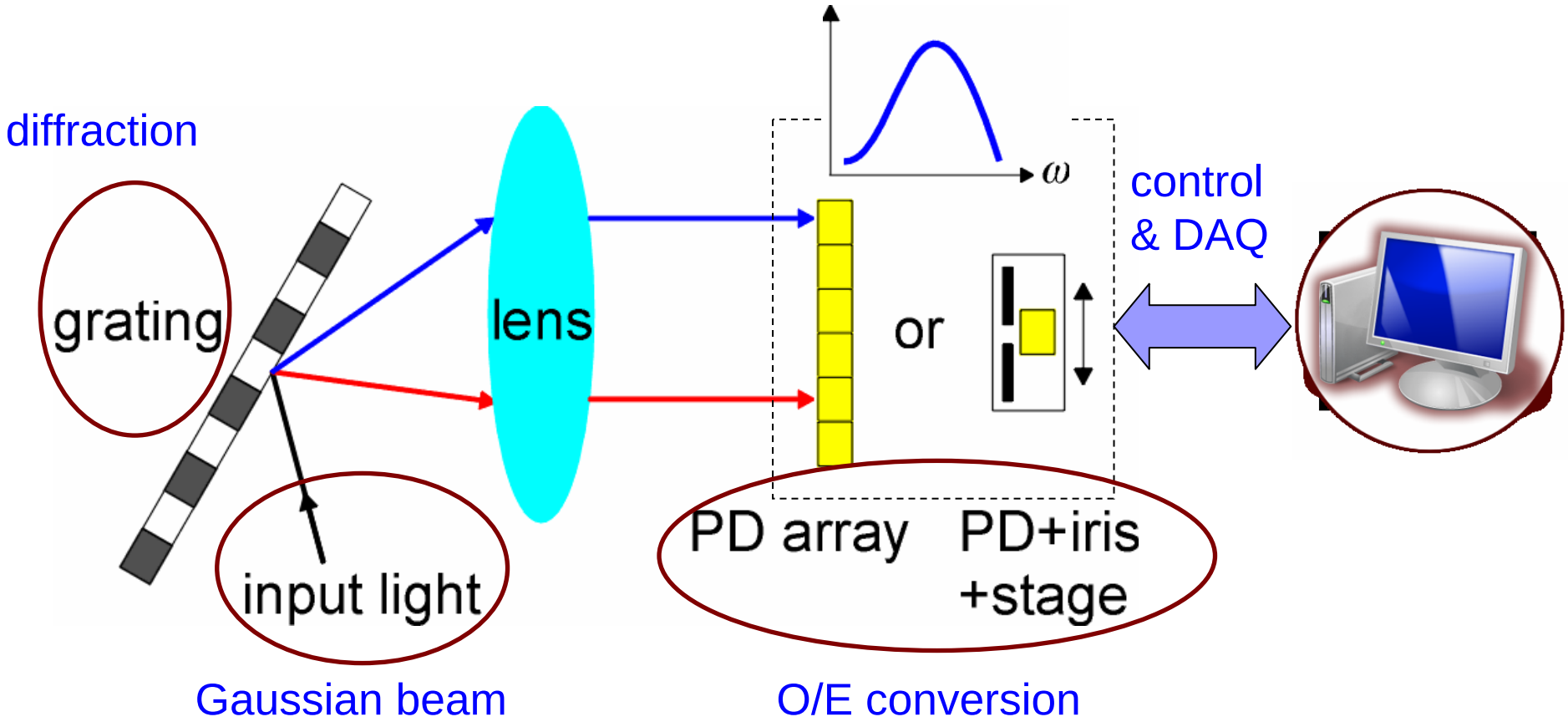
5.1 Tbit/s on a single wavelength channel using 410 fs pulses has been demonstrated

(H. C. Hansen Mulvad, et. al. Opt. Express, 2010)

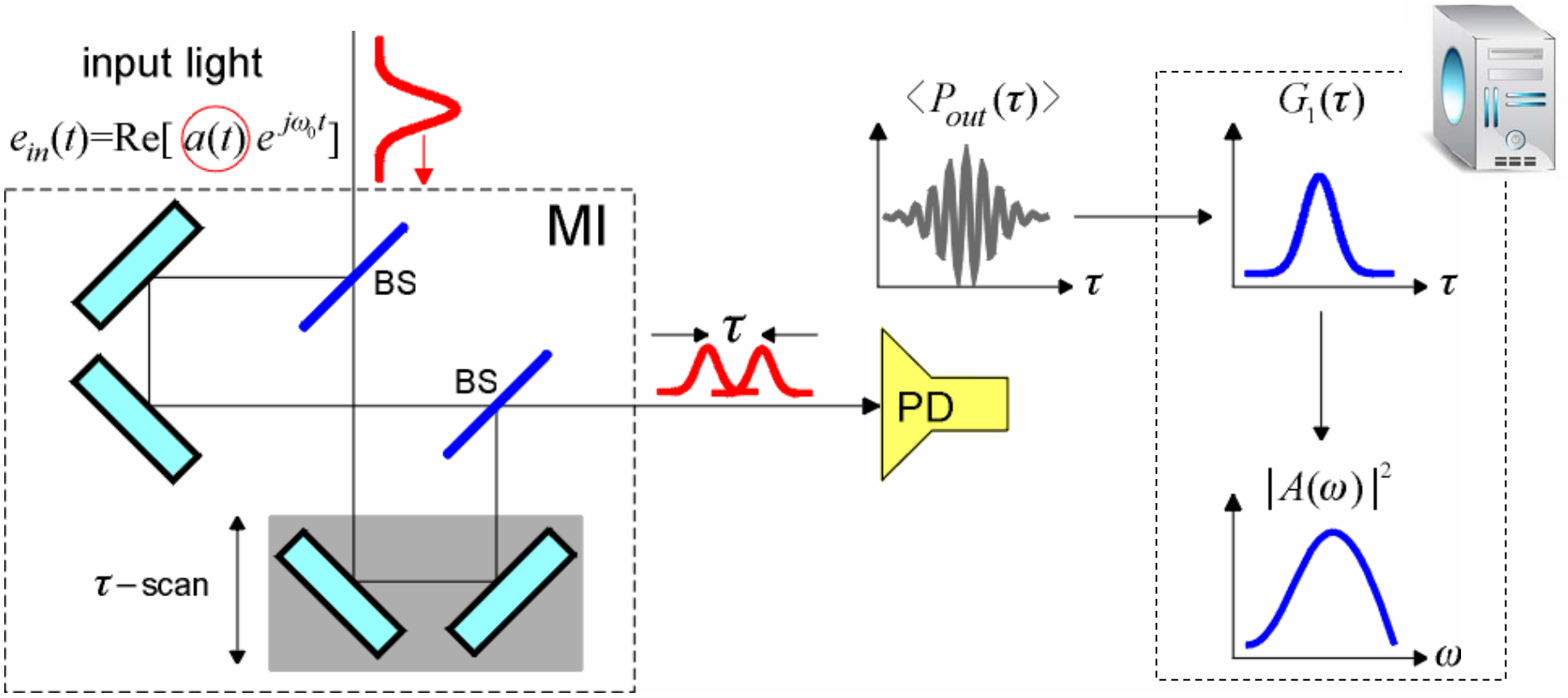
專題內容一

基礎光電儀器

繞射式光譜儀


diffraction
grating
lens
input light
ω
or
control
& DAQ
PD array
PD+iris
+stage
Gaussian beam
O/E conversion

干涉式光譜儀



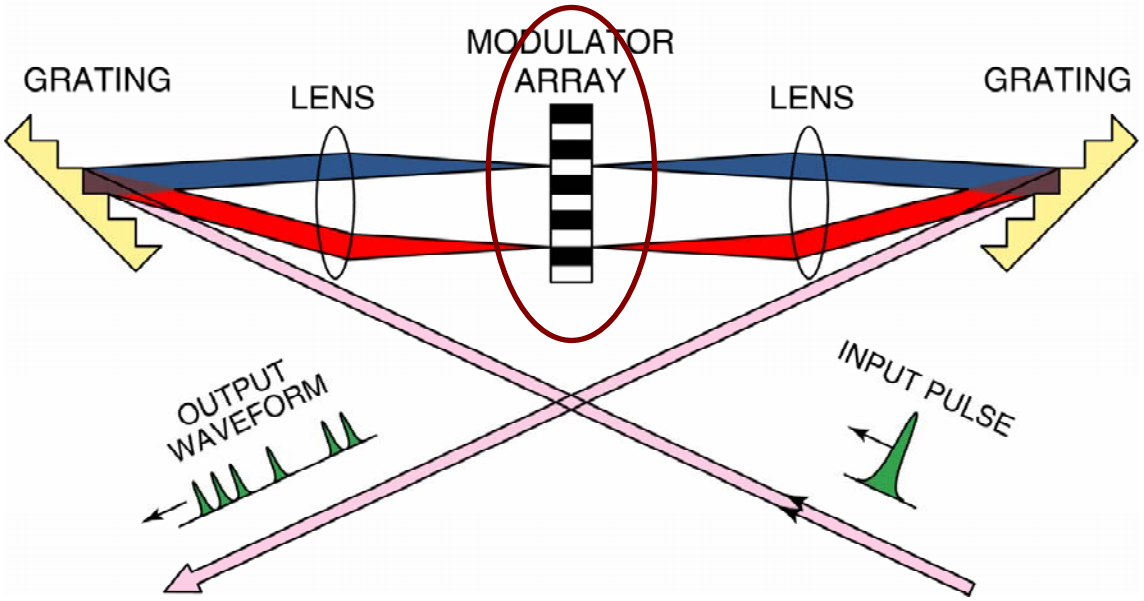
$$G_1(\tau) \propto \int a(t)a^*(t-\tau)dt, \quad F\{G_1(\tau)\} \propto |A(\omega)|^2$$

專題內容二

光脈衝塑形器

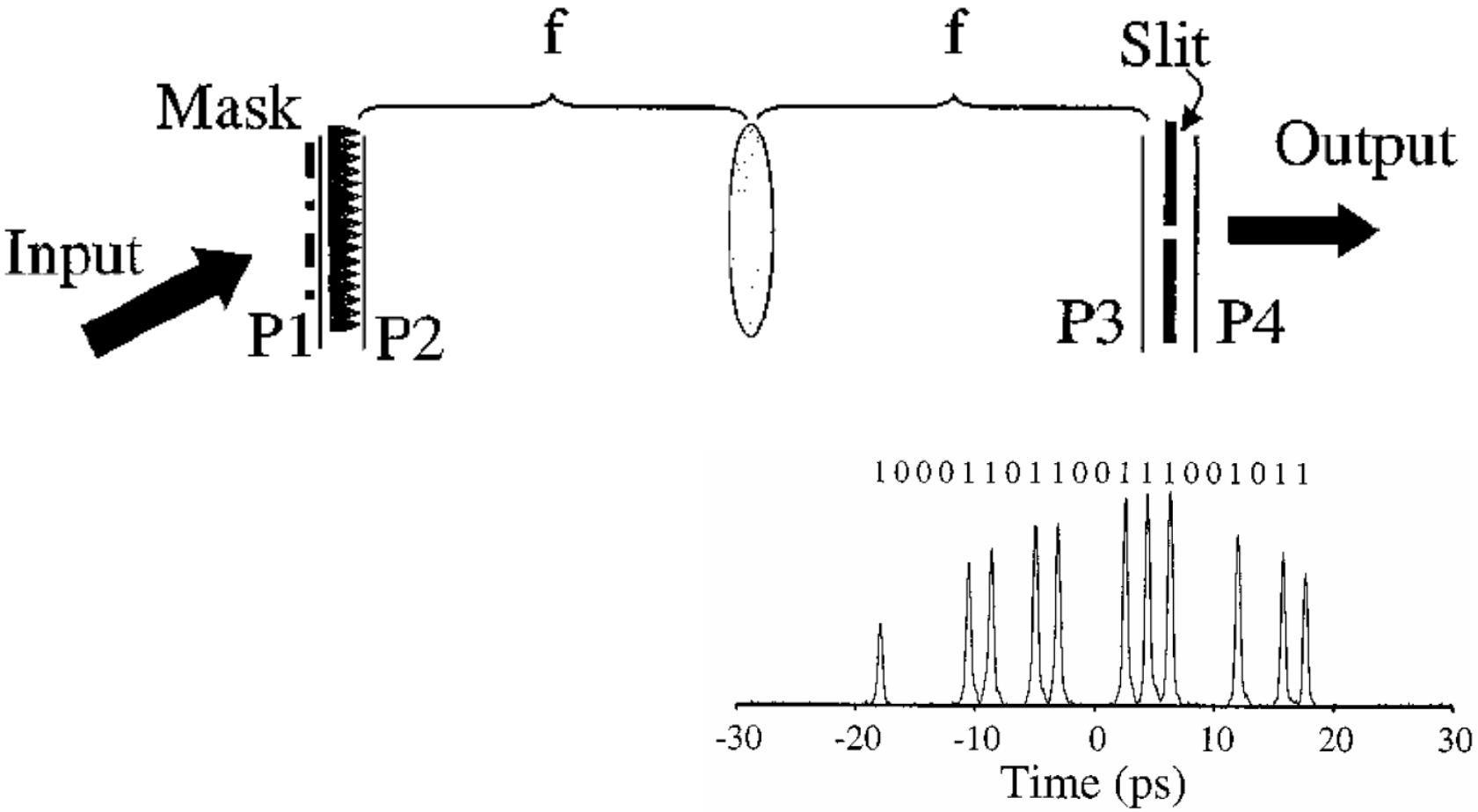
傅力葉光脈衝塑形器

polarization,
birefringence,
AM/PM masks



waveform
measurements?

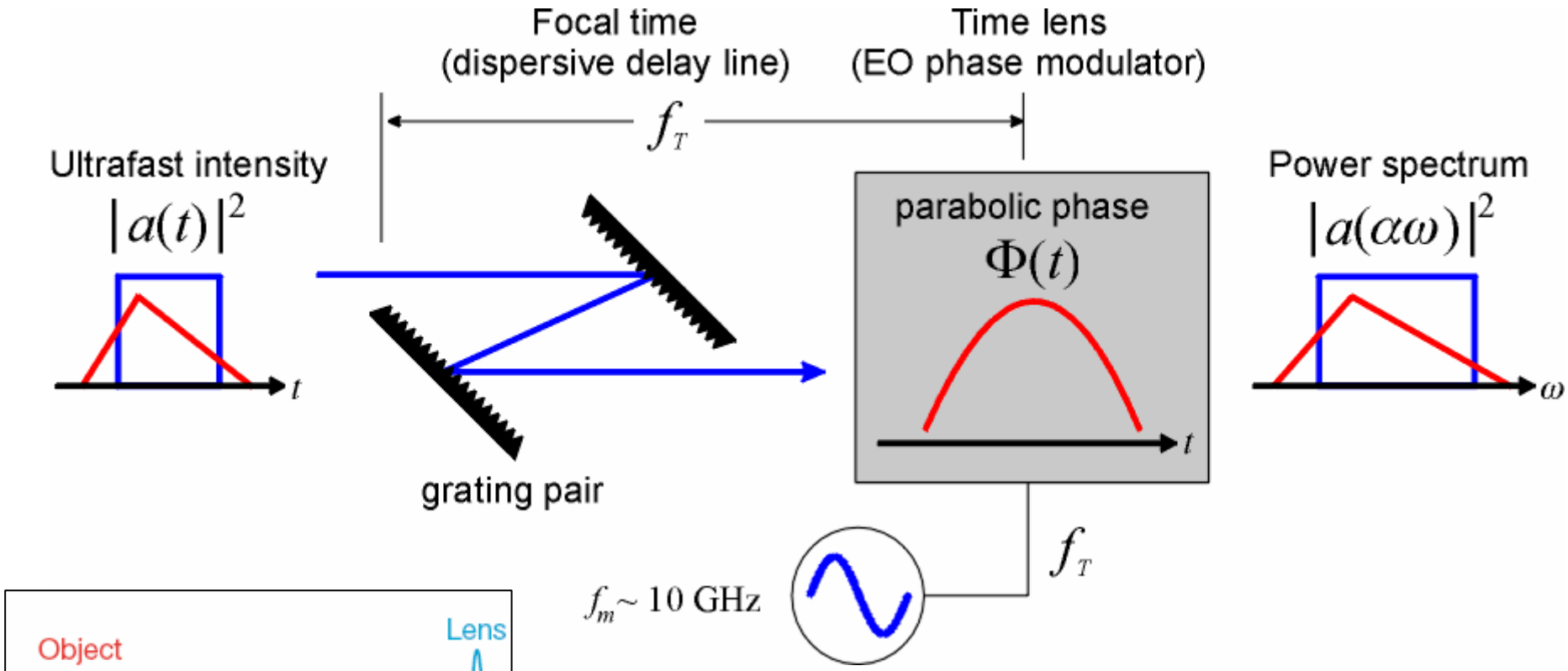
直接空間轉時間光脈衝塑形器

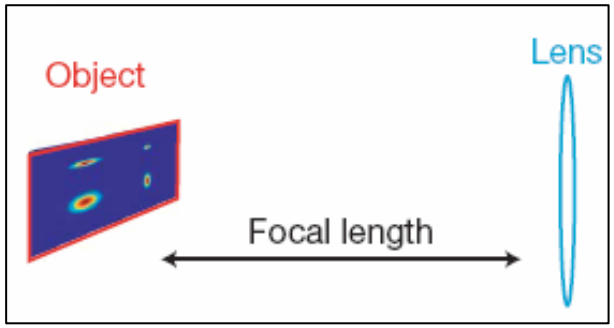


專題內容三

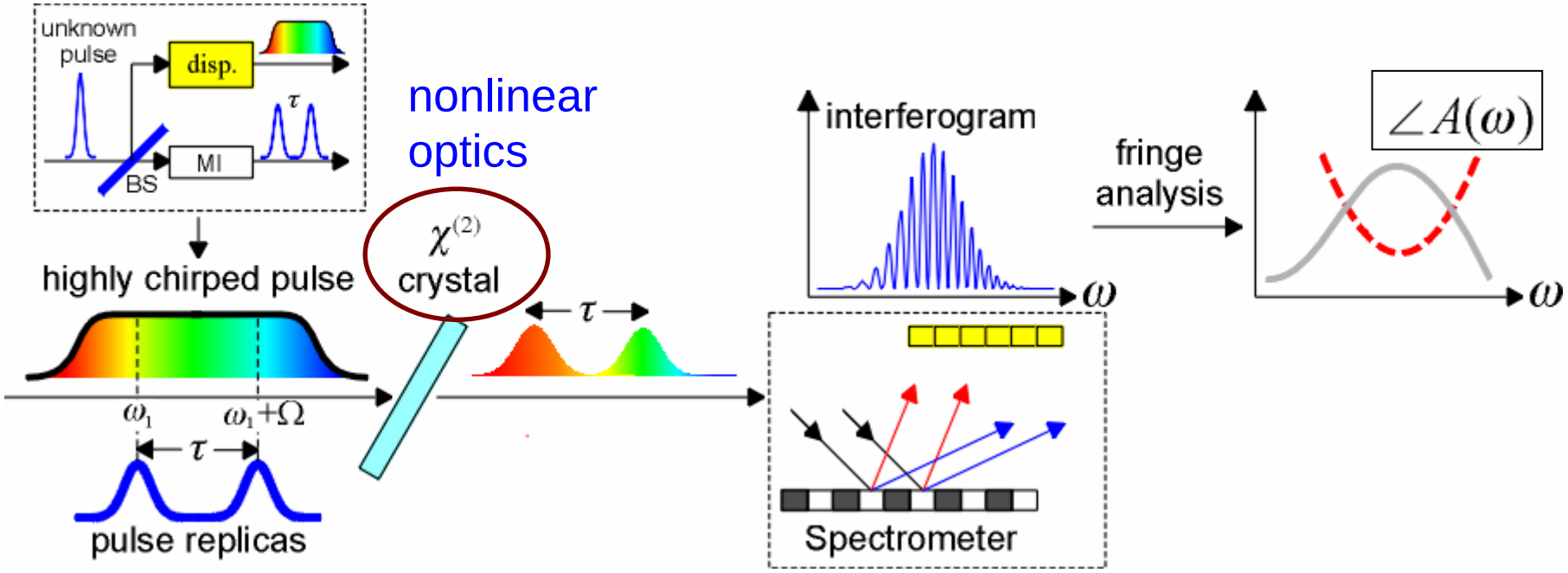
進階光電儀器(範例)

光學示波器


Focal time
(dispersive delay line)
Time lens
(EO phase modulator)
f_T
Ultrafast intensity
$|a(t)|^2$
t
grating pair
parabolic phase
$\Phi(t)$
t
Power spectrum
$|a(\alpha\omega)|^2$
ω
f_T
$f_m \sim 10$ GHz


Object
Lens
Focal length

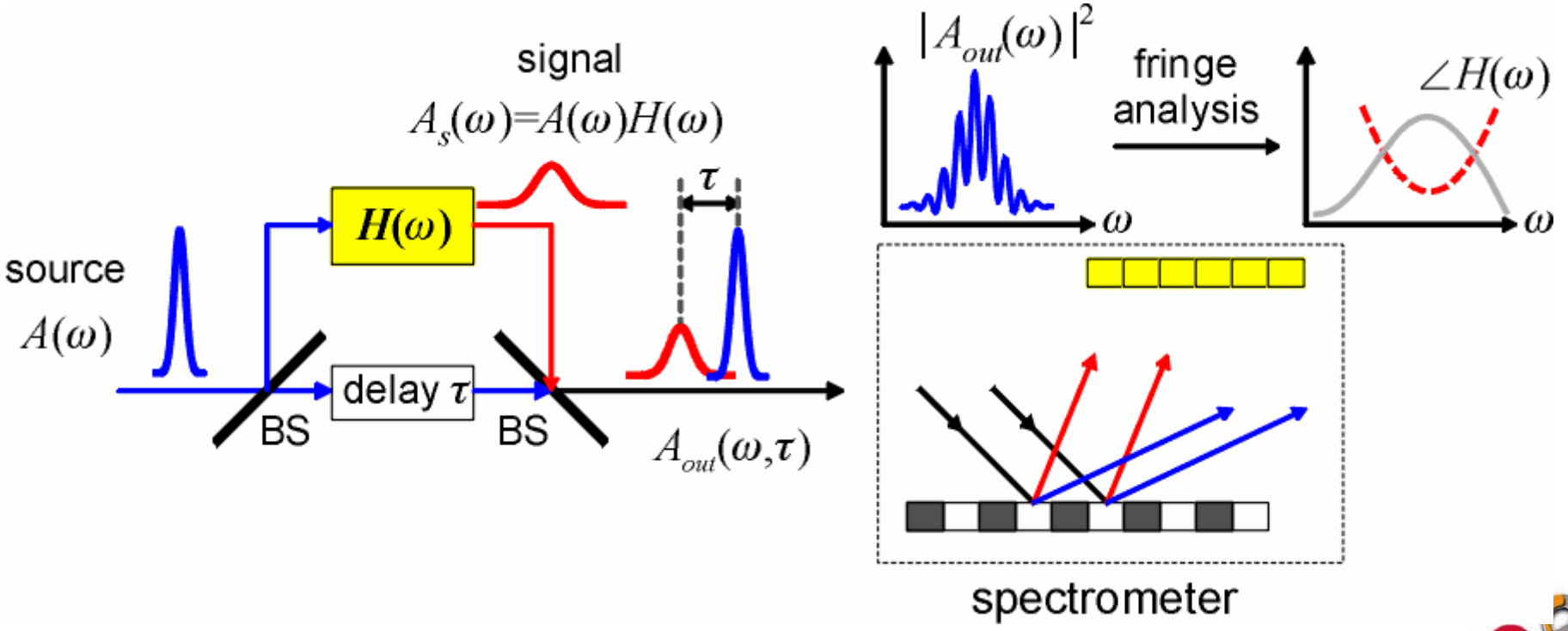
相位頻譜儀


unknown pulse
disp.
τ
MI
BS
highly chirped pulse
nonlinear optics
$\chi^{(2)}$ crystal
ω_1
$\omega_1+\Omega$
τ
pulse replicas
τ
interferogram
ω
Spectrometer
fringe analysis
$\angle A(\omega)$
ω

色散儀

Dispersion ~ frequency-dependent index of refraction

$$\angle H(\omega) \sim n(\omega)$$



專題進行方式

時間表

Winter break	Matlab, Fourier transform programming, instrumentation control via Labview & Matlab (lab)
Spring semester	Beam alignment (lab), fiber coupling (lab), beam profiling (lab), Gaussian beam (?), diffraction theory, polarization, spectrometers (lab)
Summer	Theory for FT pulse shaper and DST pulse shaper, construction of FT/DST pulse shapers (lab)
Fall semester	Ultrafast optics, advanced photonics instruments (lab)

進行方式

- 觀念與方向(advisor)，實驗技巧(seniors)
- 光譜儀、脈衝塑形器成果訂於六月、九月進行東西軍對抗
- 長假前meeting一次，規劃進度
- 期中meeting三次，檢視進度及討論問題

預期成果

- 從實驗中汲取工程經驗
- 無教科書的學習
- 發表研究成果 (09G, Optics Letters, 2009)
- 國科會專題計畫獎學金(?)