ECE 299 Holography and Coherent Imaging

Lecture 7. Information capacity of volume holograms

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Information capacity of 3-D holographic data storage

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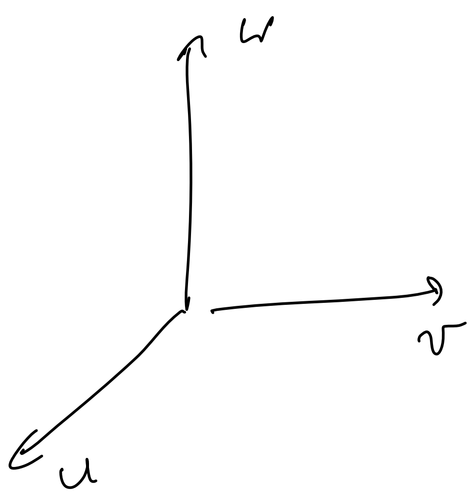
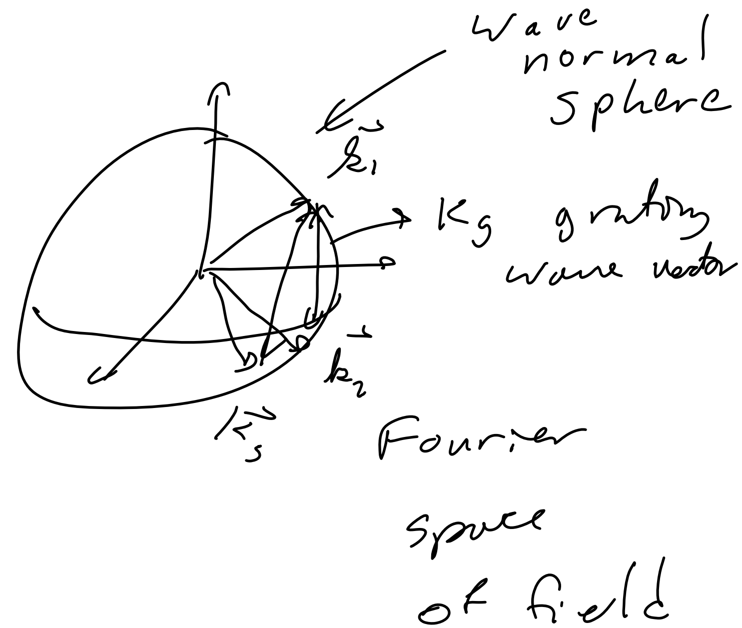
Band Volume

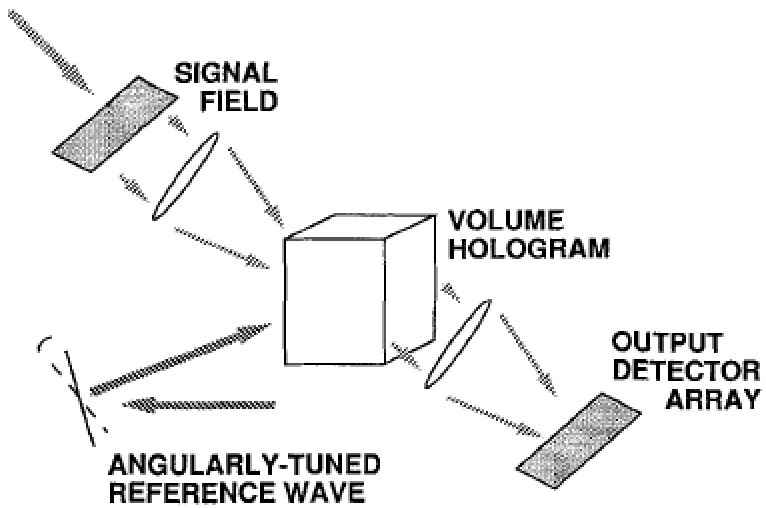
$$\Omega \leq 32\pi/3\lambda_{min}^3$$

Fourier space of medium

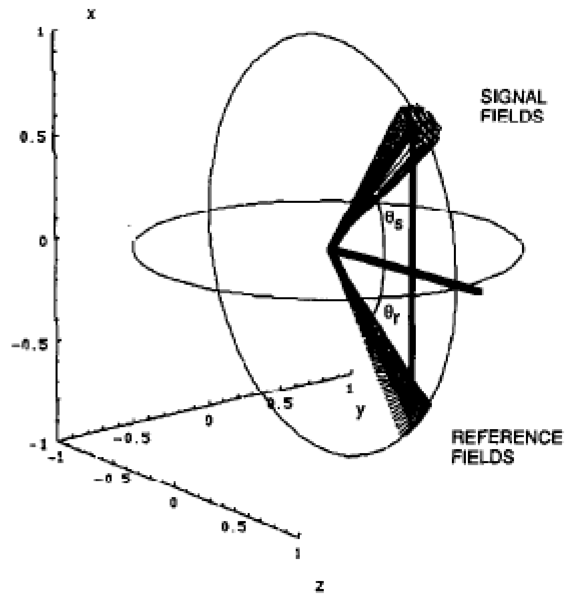




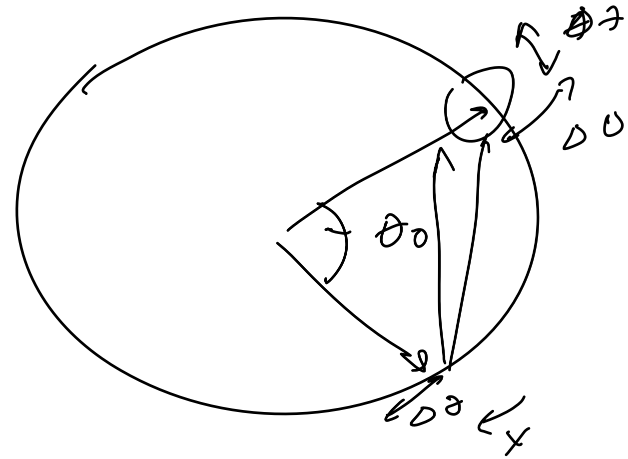
Angularly Multiplexed Data Storage



Fourier Space for Angular Multiplexing



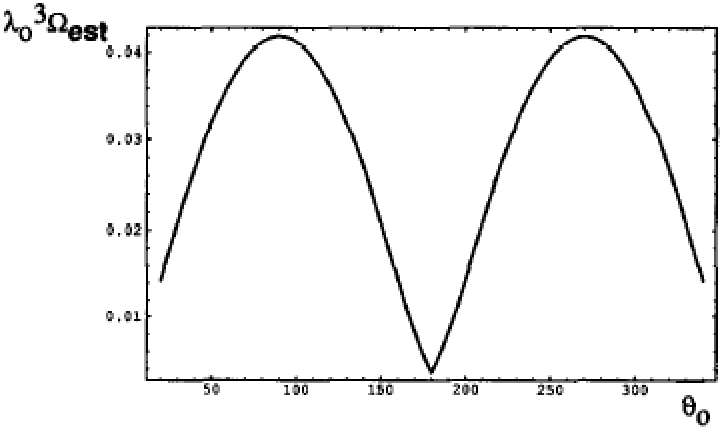
Band volume for angular multiplexing



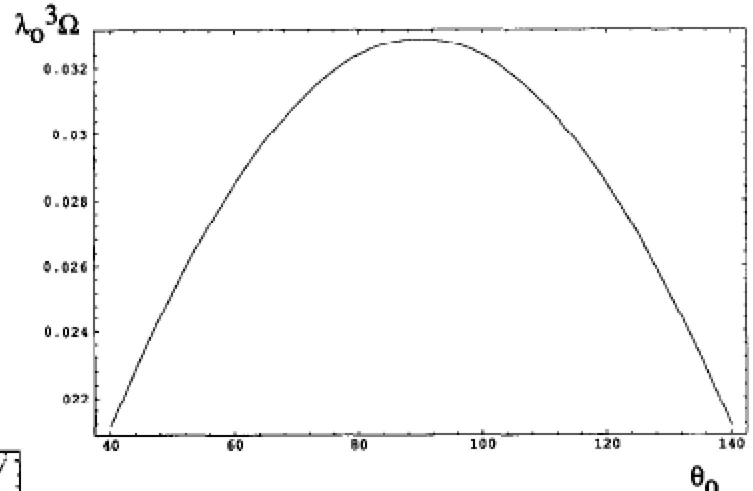
$$\Omega_{\text{est}} = (1/8\pi^3)(\text{Max}(K_{gx}) - \text{Min}(K_{gx}))(\text{Max}(K_{gy}) - \text{Min}(K_{gy}))(\text{Max}(K_{gz}) - \text{Min}(K_{gz}))$$

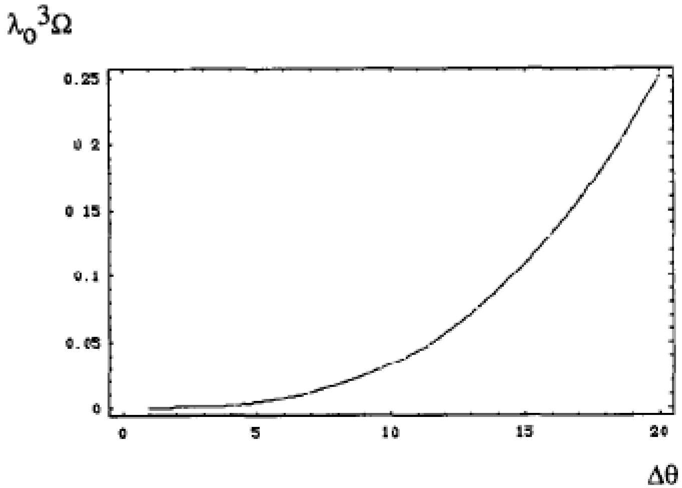
$$= \frac{8}{\lambda_0^3}\sin^2\Delta\theta\sin\frac{\theta_0}{2}\times\begin{cases} 2\cos(\theta_0/2)\sin\Delta\theta & \text{for } |\pi/2-\theta_0/2| > \Delta\theta \\ 1-\sin(\theta_0/2-\Delta\theta) & \text{for } \pi/2-\Delta\theta < \theta_0/2 < \pi/2 \\ 1-\sin(\theta_0/2+\Delta\theta) & \text{for } \pi/2+\Delta\theta > \theta_0/2 > \pi/2 \end{cases} \tag{9}$$

Numerical band volume

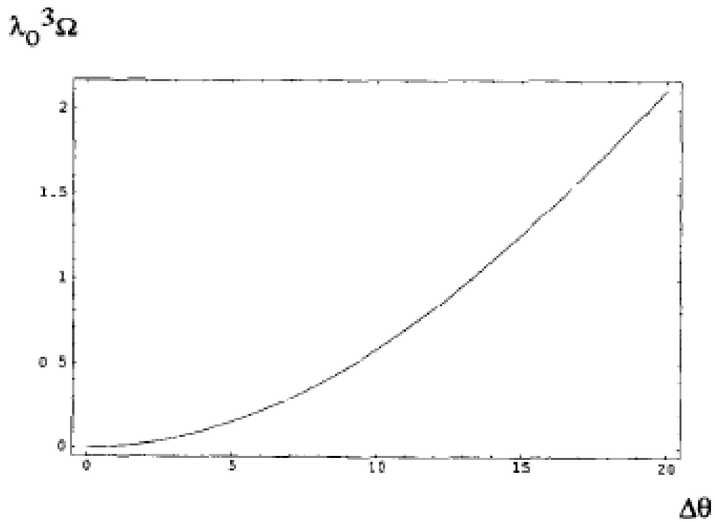


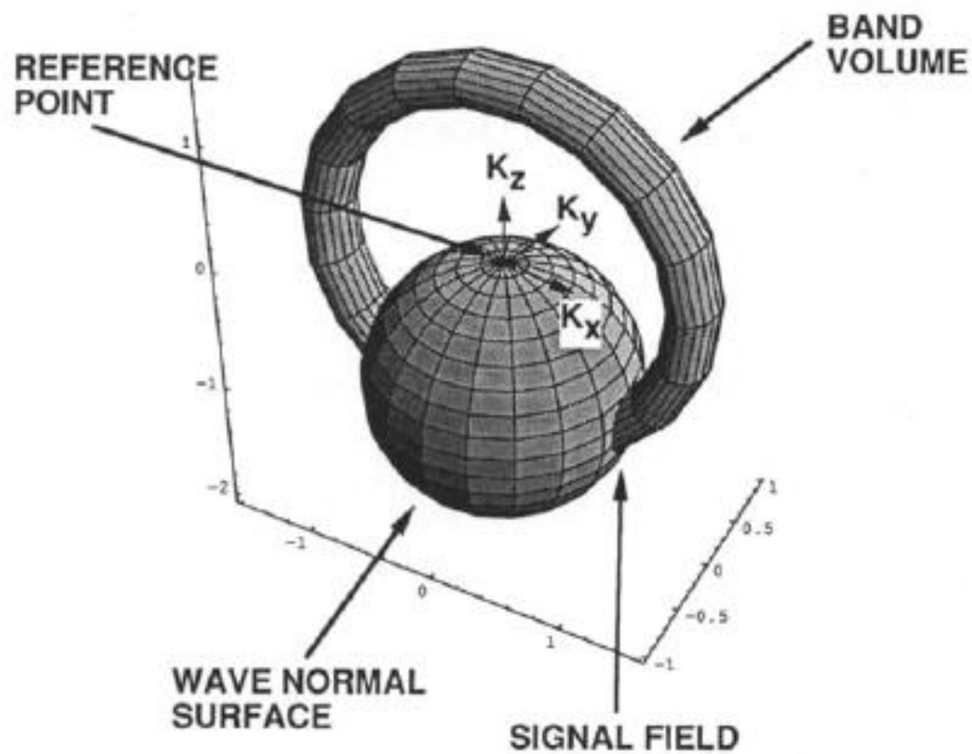
Δθ = 10°



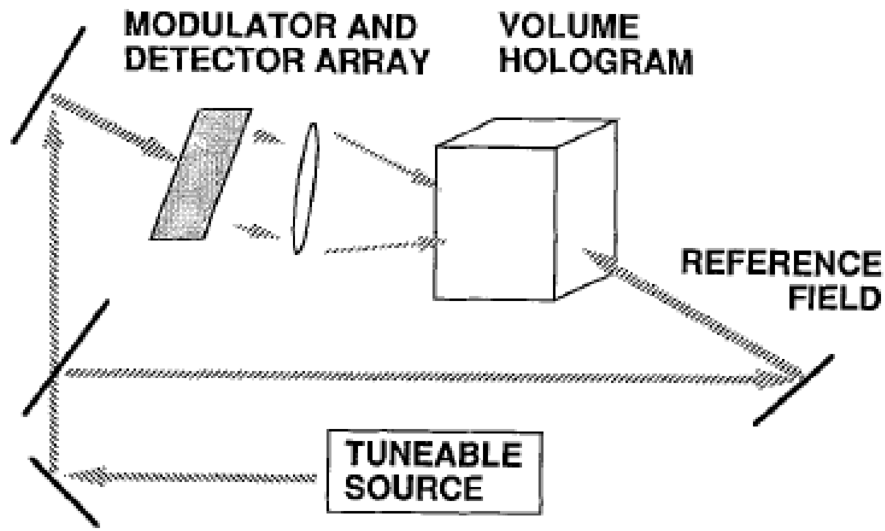


Rotating medium

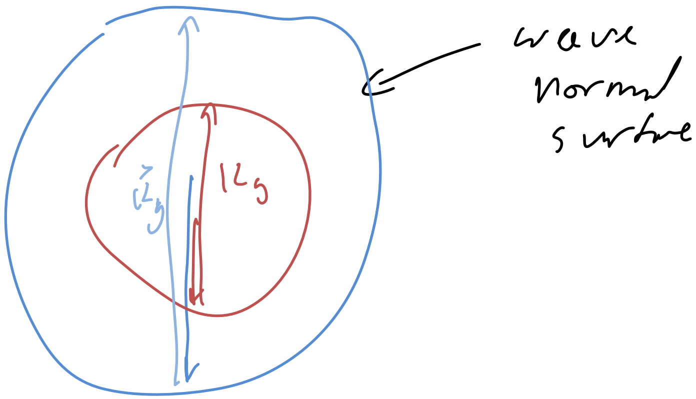


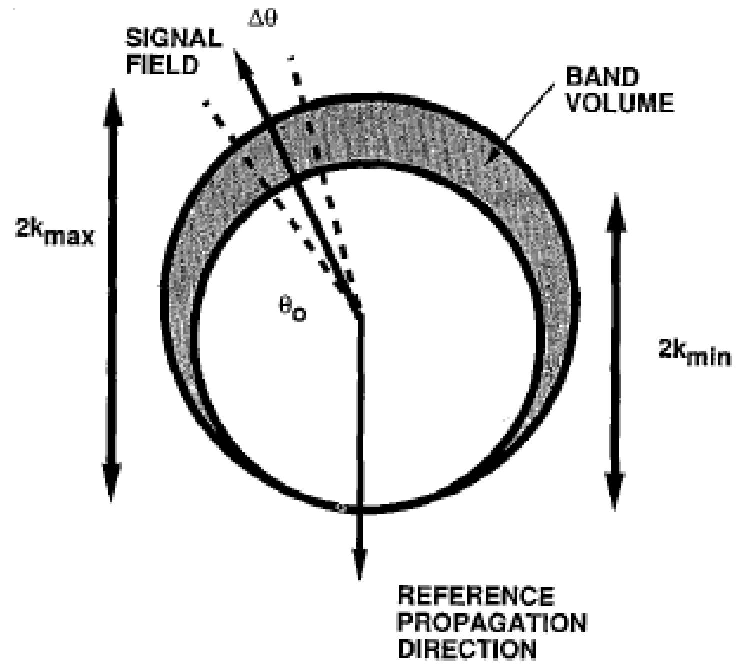


Wavelength multiplexing

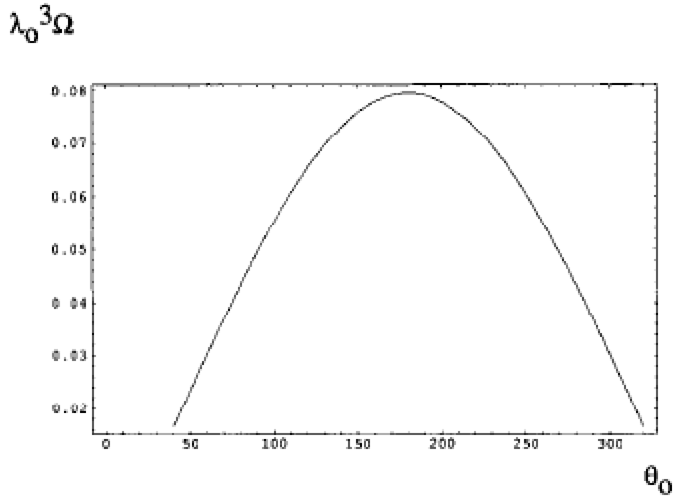


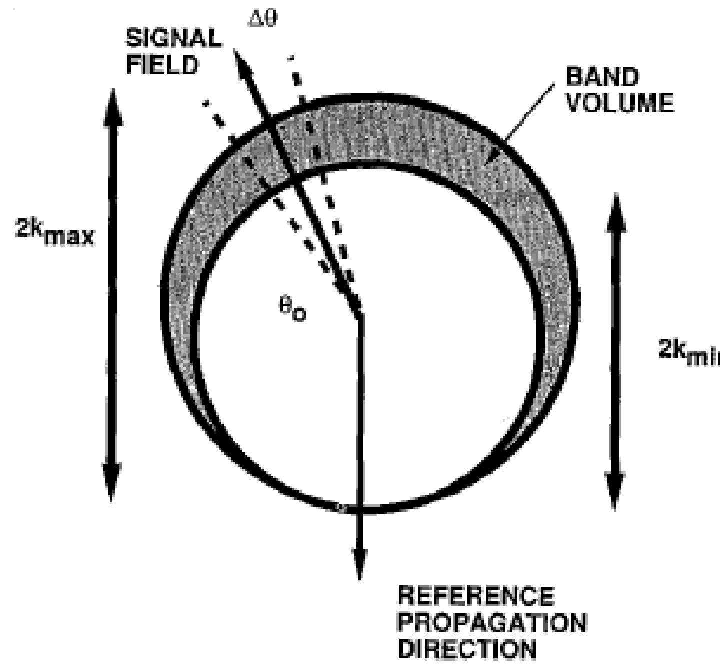
Band Volume for Wavelength Multiplexing



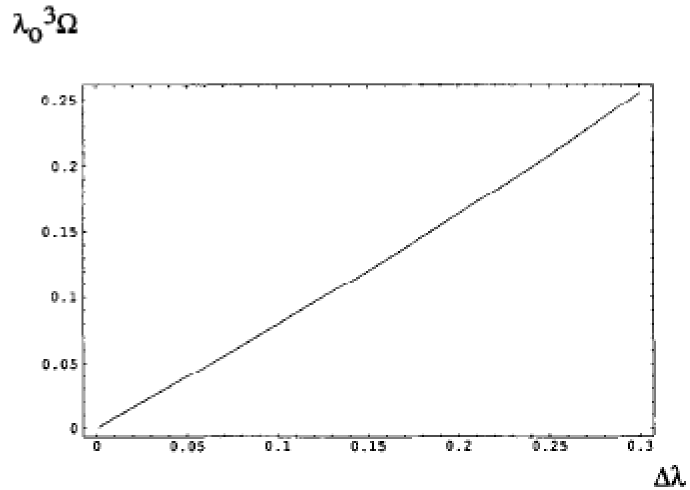


Band Volume for Wavelength Multiplexing

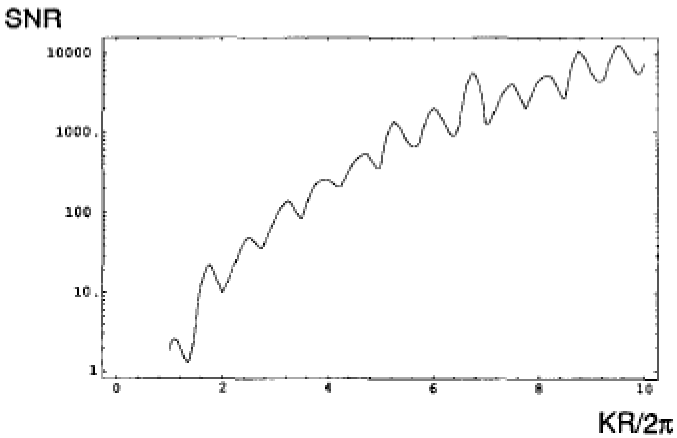




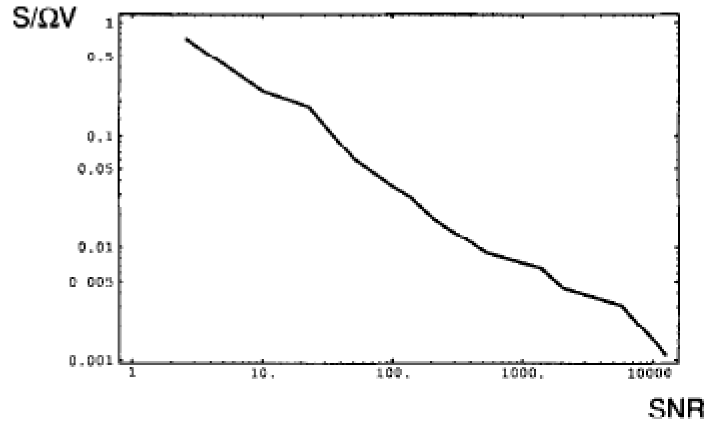
Band volume for wavelength multiplexing



Impact of reconstruction on information capacity



Ambiguity SNR



Impact of recording on information capacity

$$\eta = \frac{\eta_{\max}}{N^2 M} = \frac{\eta_{\max}}{SN}$$

$$f_{\max} = N = \frac{\Delta n}{\sqrt{\eta}} \frac{V}{\sigma^{3/2}}$$

What are the ultimate limits on volume storage?

Alternative strategies for volume storage

Time-domain frequency-selective optical data storage

Thomas W. Mossberg

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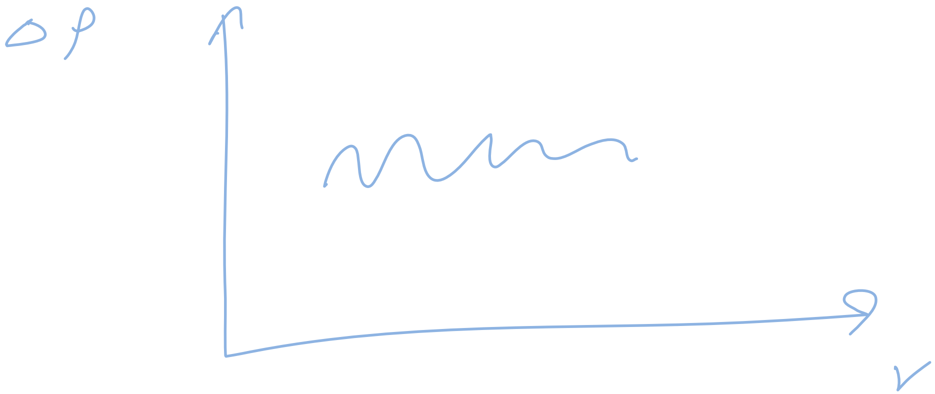
Received October 9, 1981

Thomas W. Mossberg, "Time-domain frequency-selective optical data storage," Opt. Lett. **7**, 77-79 (1982)
http://www.opticsinfobase.org/ol/abstract.cfm?URI=ol-7-2-77

Spectral Holeburning

$$\Delta\rho \propto |E(\nu)|^2$$



Spectral holeburning

$$E_p(t-\eta_p) = \mathscr{E}_p(t-\eta_p)\cos[2\pi\nu_p(t-\eta_p)+\varphi_p],$$

$$E_p(\nu_a) \equiv \int_{-\infty}^{\infty} E_p(t-\eta_p)\exp(-i2\pi\nu_a t)\,\mathrm{d}t$$

$$\theta_p(\nu_a) = \frac{2p}{\hbar}\,|E_p(\nu_a)|,$$

$$E = E_1(t) + E_2(t+\Delta t)$$

$$\rho_{gg}(\nu_a) = \cos^2[\theta_p(\nu_a)/2],$$

$$\hat{E}(\nu) = \hat{E}_1(\nu) + \hat{E}_2(\nu)\,e^{i2\pi\Delta t\nu}$$

$$\begin{aligned}\rho_{gg}(\nu_a) &= \rho_{gg}{}^{(1)} + \rho_{gg}{}^{(2)} + \rho_{gg}{}^{(12)}\\ &= \cos^2(\theta_1/2)\cos^2(\theta_2/2) + \sin^2(\theta_1/2)\sin^2(\theta_2/2)\\ &\quad - \sin(\theta_1)\sin(\theta_2)\,[E_1{}^*(\nu_a)E_2(\nu_a)\\ &\quad + E_1(\nu_a)E_2{}^*(\nu_a)]/4|E_1(\nu_a)||E_2(\nu_a)|. \qquad (4)\end{aligned}$$

Data storage in holeburning materials