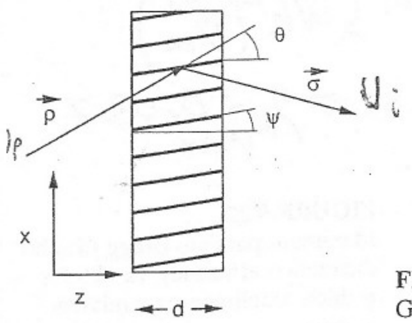


FIGURE 9.29
Geometry for analysis of a thick hologram.

The analysis

The analysis begins with the scalar wave equation,

(9-54) $$\nabla^2 U + k^2 U = 0,$$

valid in a source free region for monochromatic light. Th
general case is complex-valued, $k = (2\pi n/\lambda_o) + j\alpha$, where
and λ_o is the vacuum wavelength. The refractive index n
α within the grating are assumed to vary in sinusoidal fash

(9-55) $$\begin{aligned} n &= n_0 + n_1 \cos \vec{K} \cdot \vec{r} \\ \alpha &= \alpha_0 + \alpha_1 \cos \vec{K} \cdot \vec{r}, \end{aligned}$$

where $\vec{r} \sim (x, y, z)$ and $\vec{K}$ is the grating vector. The hologra
faces parallel to the (x, y) plane and to be of thickness d in

A number of assumptions are needed for simplification
the wave equation. First it is assumed that the hologram is t
waves need be considered within the grating. One is the r
wave $U_p(\vec{r})$, which is gradually depleted by diffraction and a
the first-order Bragg-matched grating order $U_i(\vec{r})$. We assum
the grating is composed of a sum of these two waves, and
field as

(9-56) $$\begin{aligned} U(\vec{r}) &= U_p(\vec{r}) + U_i(\vec{r}) \\ &= R(z)\, e^{j\vec{\rho}\cdot\vec{r}} + S(z)\, e^{j\vec{\sigma}\cdot\vec{r}}, \end{aligned}$$

where the symbols $\vec{\rho}$ and $\vec{\sigma}$ are conventionally used in place
$\vec{k}_i$, respectively, in our previous notation. We assume that t
that of the playback wave in the absence of coupling, and tha
diffracted wave is given by

(9-57) $$\vec{\sigma} = \vec{\rho} - \vec{K}.$$

In addition, it is assumed that absorption in a distance of on
that the variation of the refractive index is small compared t

$$\begin{aligned} n_0 k_o &\gg \alpha_0 \\ n_0 k_o &\gg \alpha_1 \\ n_0 &\gg n_1, \end{aligned} \tag{9-58}$$

e vacuum wave number, $k_o = 2\pi/\lambda_o$.
possible to expand and simplify k^2 for use in the wave equation as fol-

$$\begin{aligned} k^2 &= \left[k_o\left(n_0 + n_1 \cos \vec{K}\cdot\vec{r}\right) + j\left(\alpha_0 + \alpha_1 \cos \vec{K}\cdot\vec{r}\right)\right]^2 \\ &\approx B^2 + 2jB\alpha_0 + 4\kappa B \cos \vec{K}\cdot\vec{r}, \end{aligned} \tag{9-59}$$

se of the approximations (9-58) has been made, $B = k_o n_0$, and κ is the
ant, given by

$$\kappa = \tfrac{1}{2}\left(k_o n_1 + j\alpha_1\right). \tag{9-60}$$

ep is to substitute the assumed solution (9-56) and the expression for k^2
vave equation (9-54). During the substitution, $R(z)$ and $S(z)$ are assumed
rying functions of z so that their second derivatives can be dropped,
$\cdot\, \vec{r}$ is expanded into its two complex-exponential components, and $\vec{\sigma}$
rding to (9-57). Terms with wave vectors $\vec{\sigma} - \vec{K} = \vec{\rho} - 2\vec{K}$ and $\vec{\rho} +$
e dropped, since they correspond to propagation directions that are far
the Bragg condition. Finally, equating the sum of all terms multiplying
ro and similarly for the sum of all terms multiplying $\exp[j\vec{\sigma}\cdot\vec{r}]$, we
d $S(z)$ must individually satisfy the following equations in order for the
be satisfied:

$$\begin{aligned} c_R \frac{dR}{dz} + \alpha_0 R &= j\kappa S \\ c_S \frac{dS}{dz} + \left(\alpha_0 - j\zeta\right) S &= j\kappa R, \end{aligned} \tag{9-61}$$

the "detuning parameter", given by

$$\zeta = \frac{B^2 - |\vec{\sigma}|^2}{2B}, \tag{9-62}$$

c_R and c_S are given by

$$\begin{aligned} c_R &= \frac{\rho_Z}{B} = \cos\theta \\ c_S &= \frac{\sigma_Z}{B} = \cos\left(\theta - 2\psi\right), \end{aligned} \tag{9-63}$$

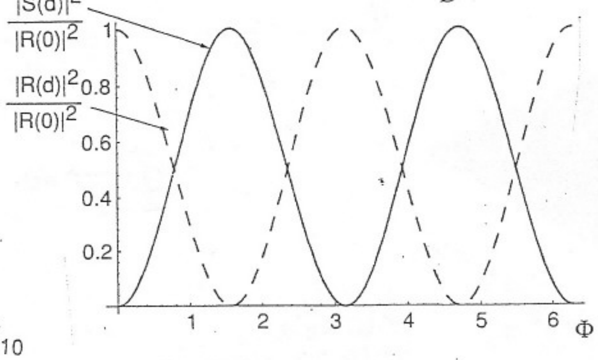


FIGURE 9.30
Normalized intensities of the diffracted and undiffracted waves as a function of Φ for the Bragg matched case.

$$\eta = \sin^2 \Phi$$

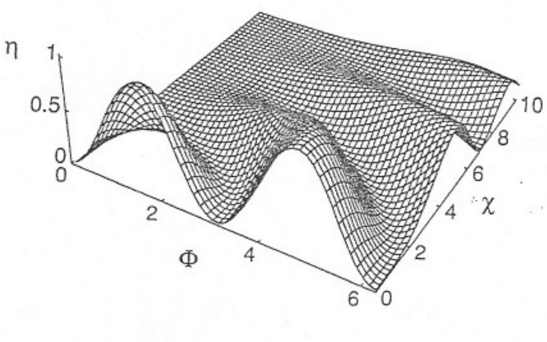
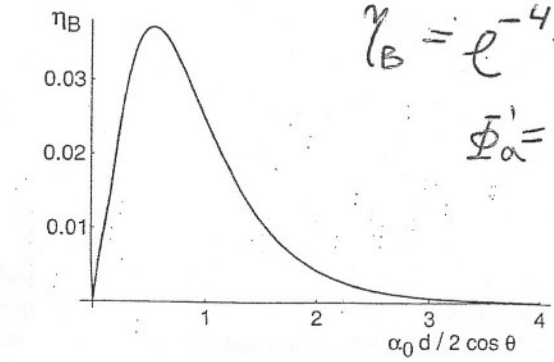


FIGURE 9.31
Diffraction efficiency of a thick phase transmission grating when Bragg mismatch is present.

$$\Phi = \frac{\pi n_1 d}{\lambda \cos\theta}$$

$$\chi = \frac{Kd}{2\cos\theta}\left[\Delta\theta \cos(\theta - \psi) - \frac{\Delta\lambda}{2\Lambda}\right]$$



$$\eta_B = e^{-4\Phi_a'}\sinh^2(\Phi_a')$$

$$\Phi_a' = 0.55 \Rightarrow \eta_{B,MAX} = 0.037$$

FIGURE 9.32
Maximum possible Bragg matched diffraction efficiency vs. Φ_a' for a thick amplitude transmission grating.

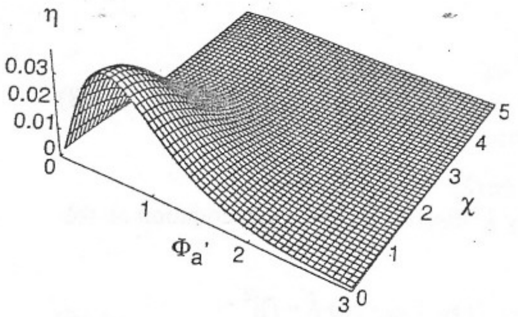
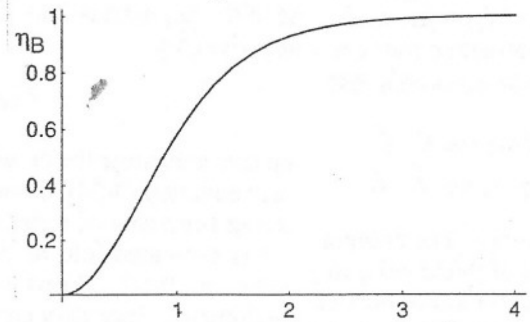


FIGURE 9.33
Diffraction efficiency of a thick amplitude transmission grating with Bragg mismatch.

$$\Phi_a' = \alpha_0 d / 2\cos\theta$$



$$\eta_B = \tanh^2\Phi$$

$$\eta_{B,MAX} = 1$$

FIGURE 9.34
Diffraction efficiency of a thick Bragg matched phase reflection grating.

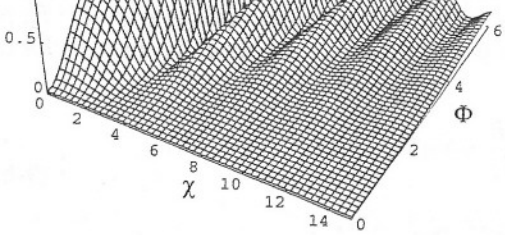
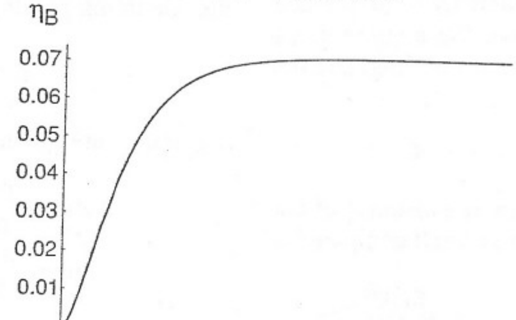


FIGURE 9.35
Diffraction efficiency of a thick phase reflection grating when Bragg mismatch is present.



$$\Phi_a = \frac{\alpha_1 d}{2\cos\theta}$$

$$\eta_B = \left[2 + \sqrt{3}\coth\left(\sqrt{3}\,\Phi_a\right)\right]^{-2}$$

FIGURE 9.36
Bragg matched diffraction efficiency of a thick amplitude reflection grating.

$$\Phi_a \to \infty \Rightarrow \eta_{B,MAX} = 0.072$$

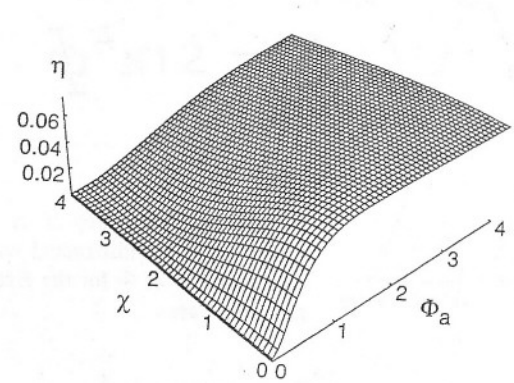
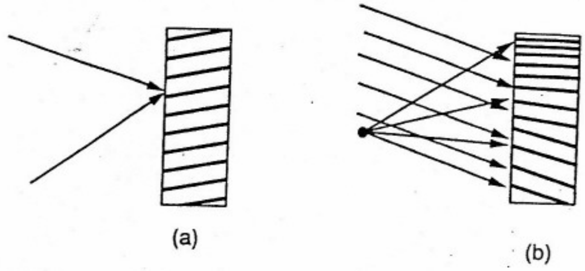


FIGURE 9.37
Diffraction efficiency of a thick amplitude hologram when Bragg mismatch is present.

$\eta = \sin^2\Phi$



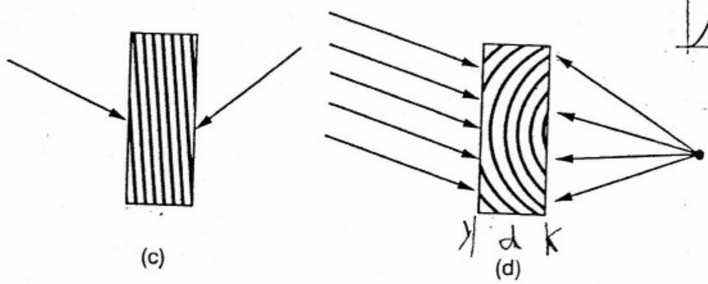


FIGURE 9.26
Orientation of interference fringes within a recording medium. (a) Two plane waves forming slant fringes, (b) a plane wave and a spherical wave, (c) two plane waves impinging from opposite sides of the emulsion, and (d) a plane wave and a spherical wave impinging from opposite sides of the recording medium.

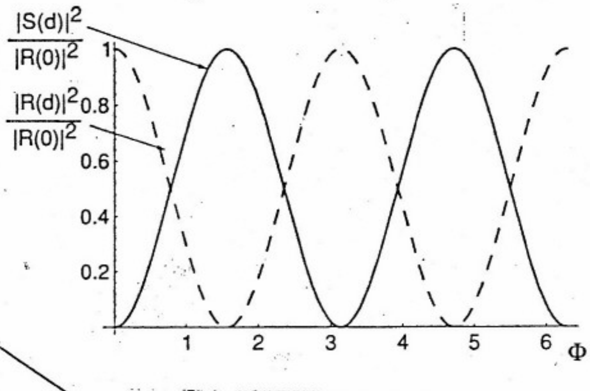
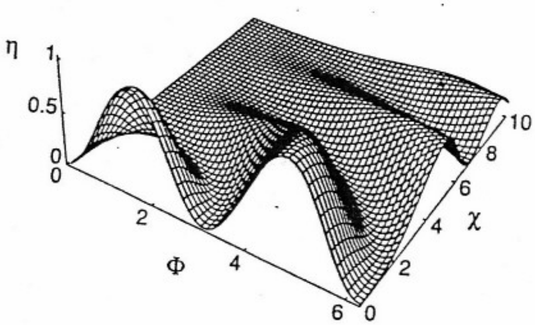


FIGURE 9.30
Normalized intensities of the diffracted and undiffracted wa as a function of Φ for the Bra matched case.

$$\Phi = \frac{\pi \Delta n_{mx} d}{\lambda \cos\theta}$$

$$\chi = \frac{\pi d}{\Lambda \cos\theta}\left[\Delta\theta \cos\theta - \frac{\Delta\lambda}{2\Lambda}\right]$$

$$n = n_0 + \Delta n \cos(\vec{K}_g \cdot \vec{r})$$



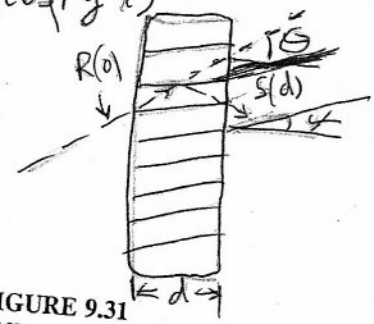


FIGURE 9.31
Diffraction efficiency of a thick phase transmission grating when Bragg mismatch is present.

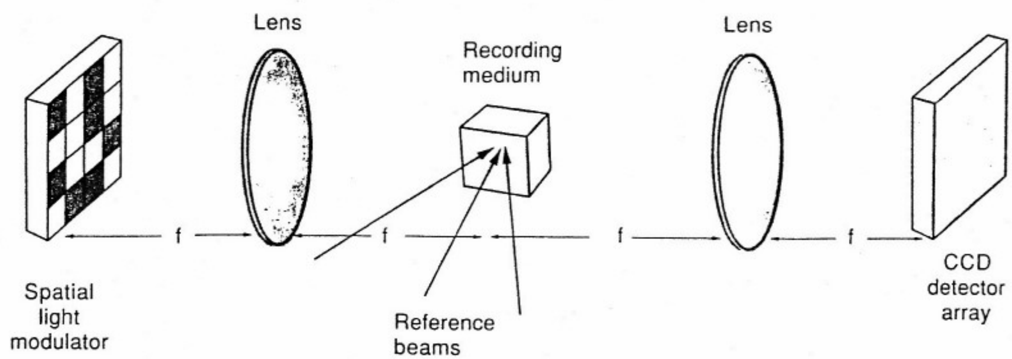


FIGURE 9.57
A volume holographic storage system. The case of angle multiplexing is illustrated.

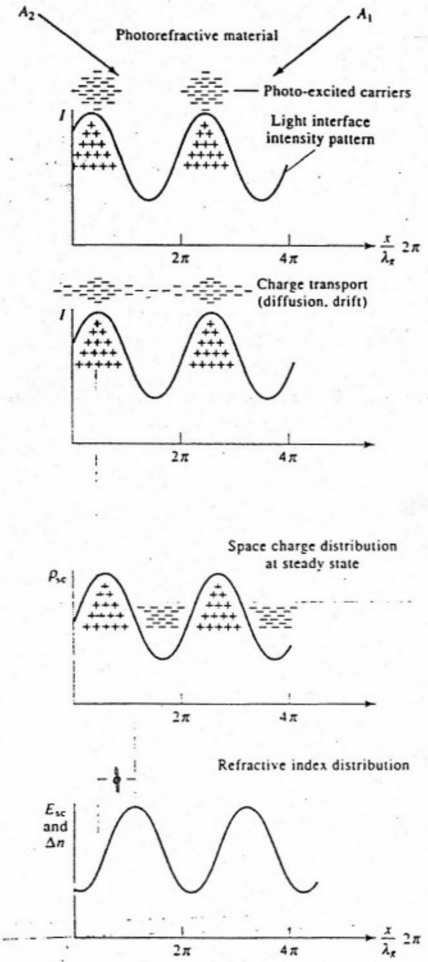


Figure 18-2 The photorefractive mechanism. Two coherent light beams intersect in an electrooptic crystal, forming an interference pattern. Electrons are excited where the intensity is large and migrate to regions of low intensity. The electric field associated with the resultant space charge operates through the electrooptic effect to produce a refractive index grating. ϕ is the phase shift (in radians) between the light interference pattern and the index grating.

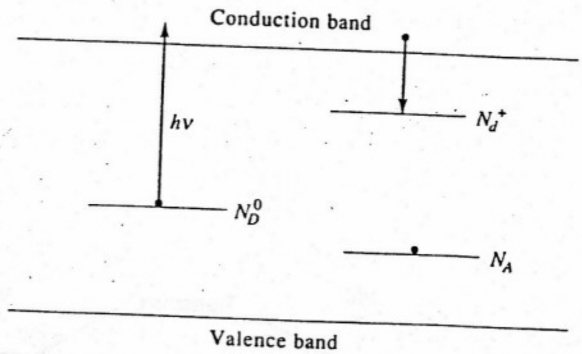


Figure 18-3 The deep impurity levels involved in the charge migration and trapping of a photorefractive crystal.

$$\nabla \cdot \vec{E} = \frac{\rho_{sc}}{\varepsilon}$$

$$E_{sc} = \int \frac{\rho_{sc}}{\varepsilon}\, dx$$

$$\Delta n = \frac{1}{2} n_o^3 r_e E_{sc}$$

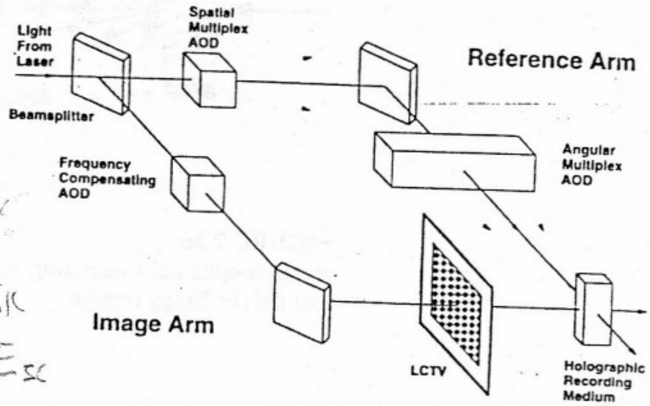


Fig. 11 Holographic memory demonstrator system layout.

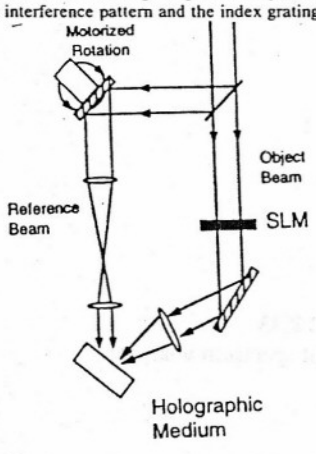


Fig. 7 Simplified angularly multiplexed storage system.

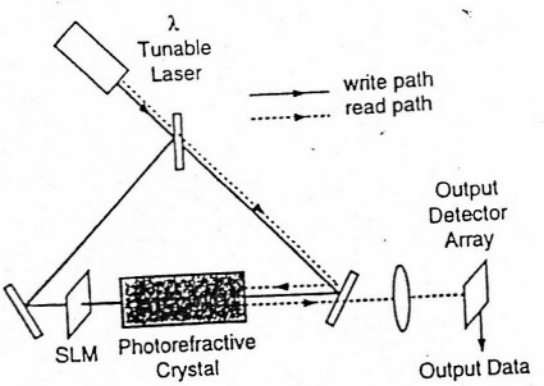


Fig. 9 Simplified wavelength multiplexed storage system.

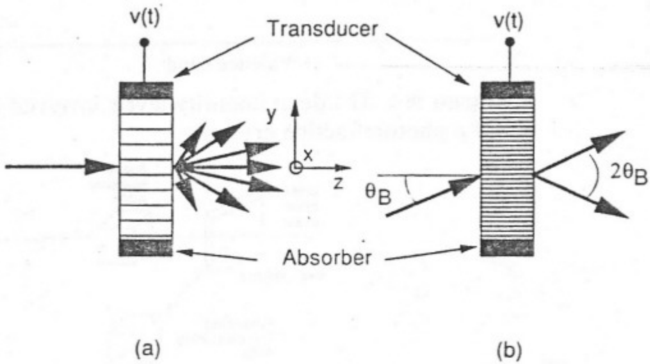


FIGURE 7.26
Acousto-optic cells operating in the (a) Raman-Nath regime and the (b) Bragg regime.

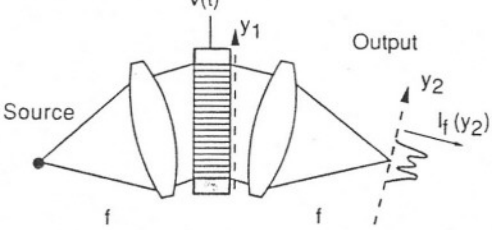


FIGURE 8.33
Bragg cell spectrum analyzer.

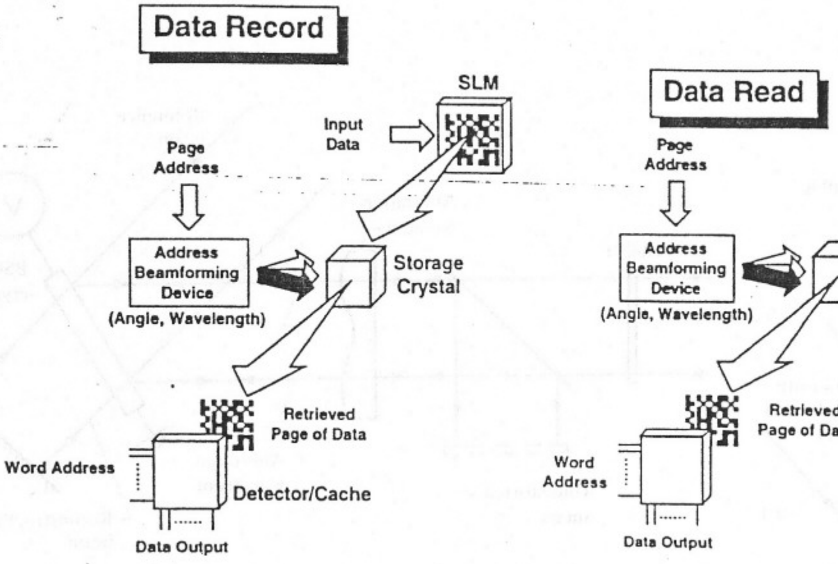


Fig. 1 Simplified system diagram of holographic mass memory.

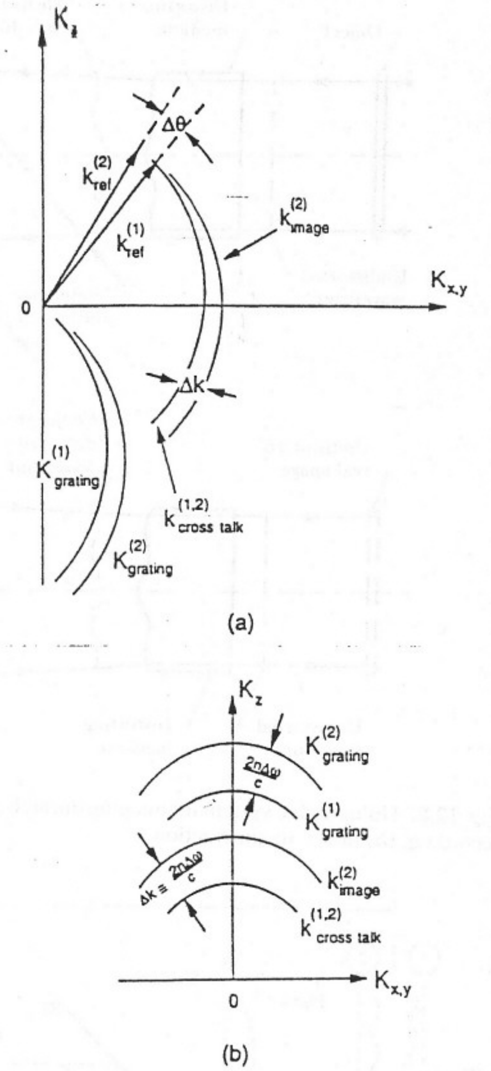


Figure 1-2. K space diagrams for volume holography using (a) angle-multiplexing scheme, (b) orthogonal multiplexing schem

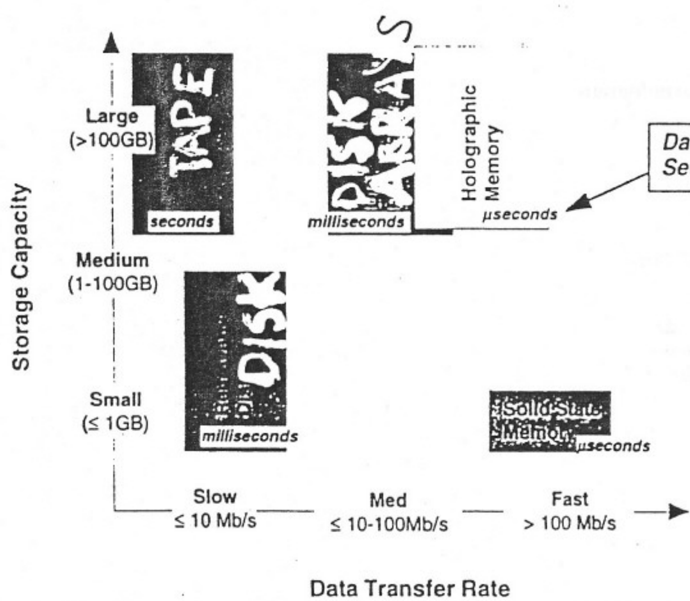


Fig. 2 Data storage technology spectrum.

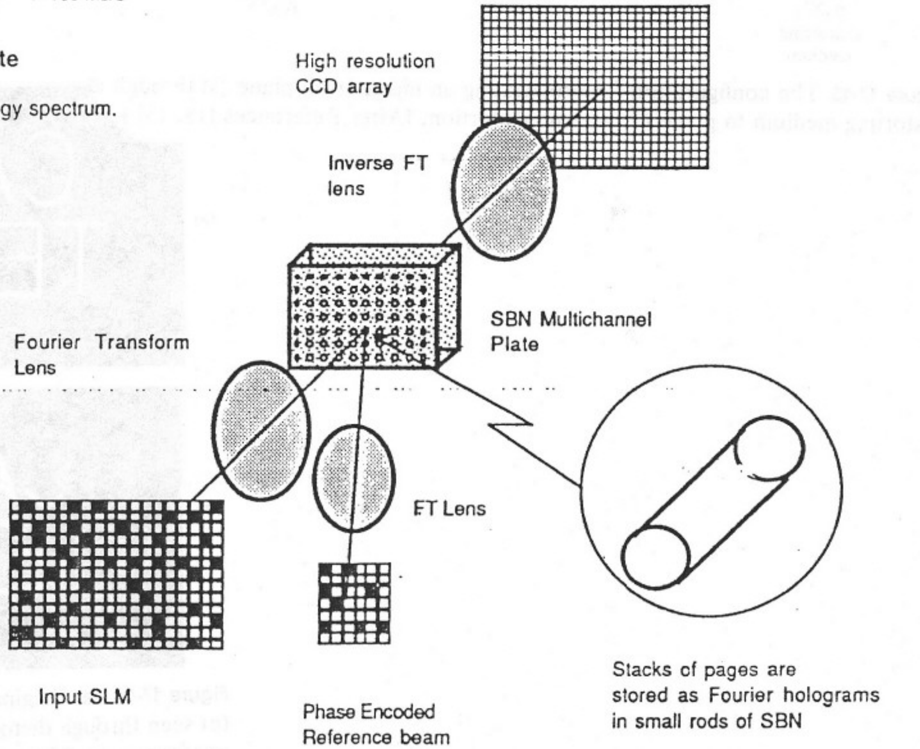


Figure 1 Schematic of a high-density, high-bandwidth data storage architecture.

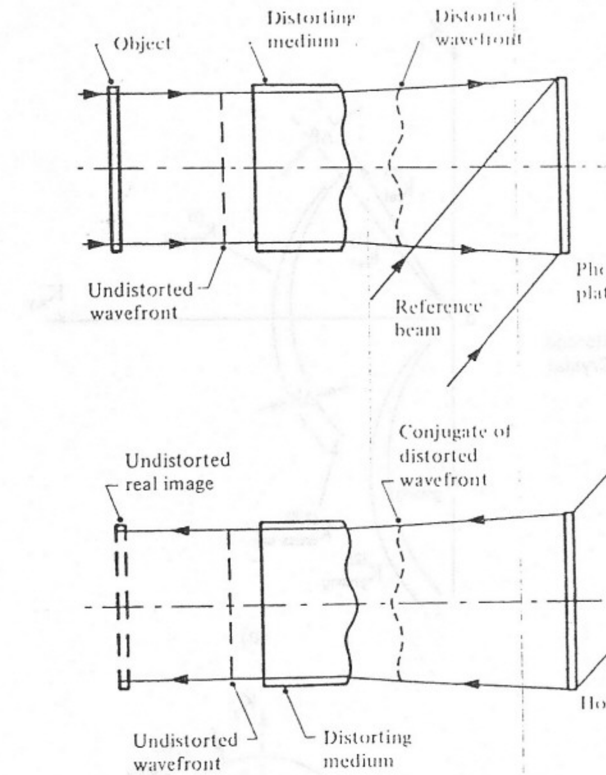
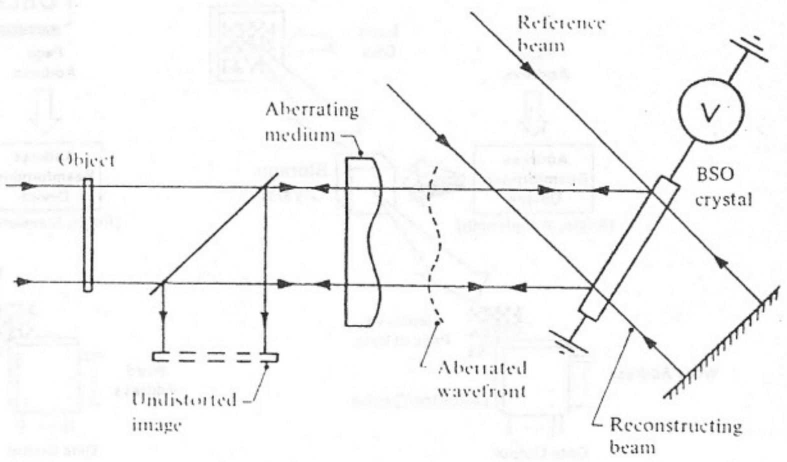
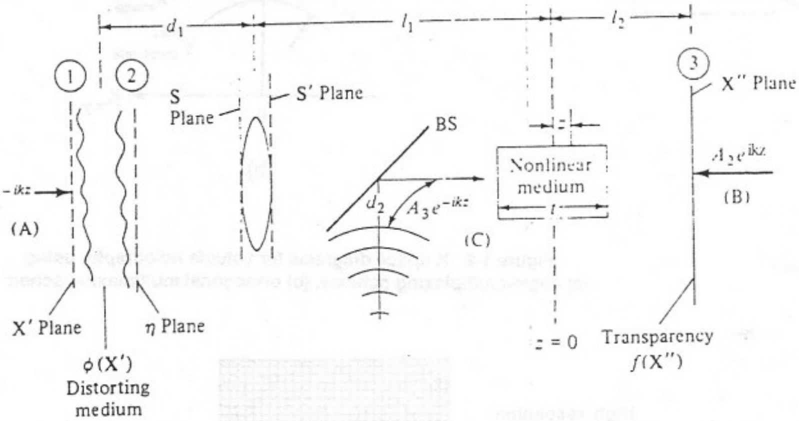


Fig. 12.2. Holographic system for imaging through an aberrating medium: (a) hologram recording, (b) image reconstruction.



3. Real time imaging through an aberrating medium [Huignard *et al.*, 197



gure 17-13. The configuration for propagating an image from plane (3) through a istorting medium to plane (1) with no distortion. (After References [18, 19].)

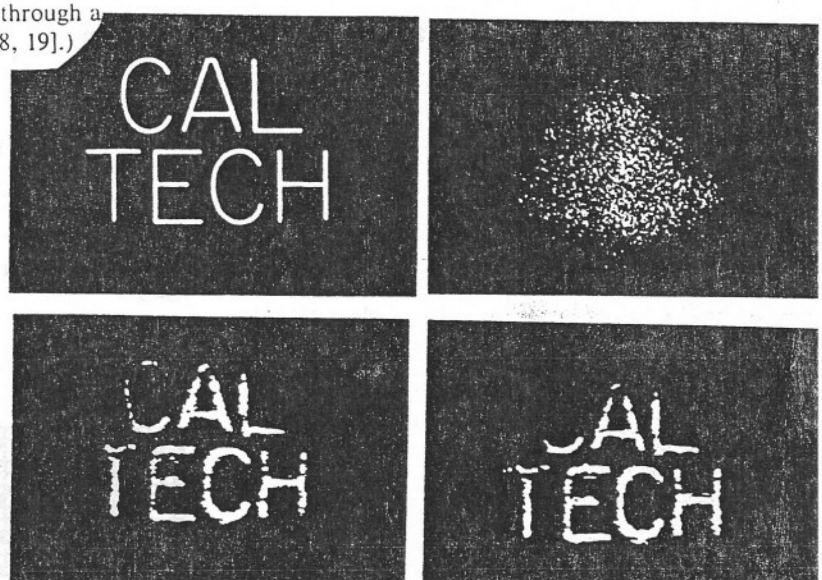


Figure 17-14 (a) Original transparency. (b) seen through distortion (no correction (c) seen through distortion–phase conjugate window combination using configuration of Figure 17-13. and (d) seen through phase conjugate window (nc distortion).