@PKU, 2013-11-13

Nondiffracting beams: playing a game of wave-equation

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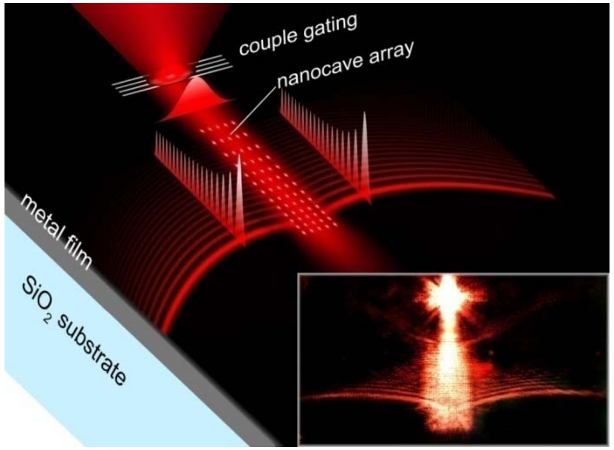
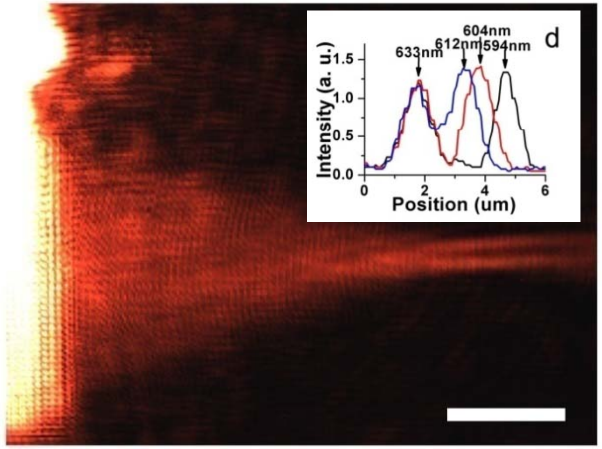
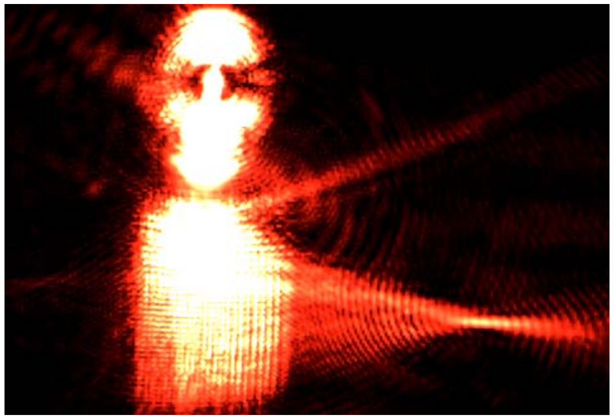
Review the talk in July-13



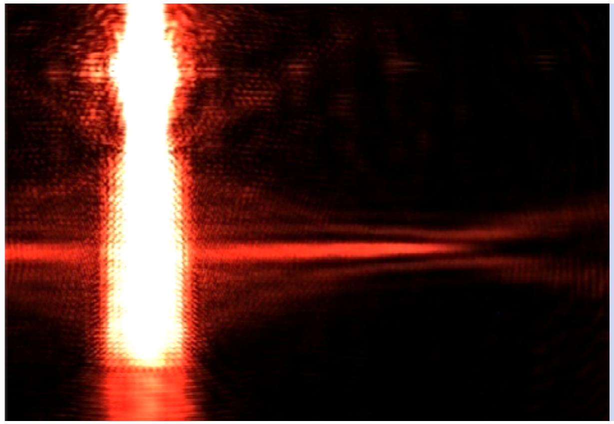
Nondiffracting SPP Airy beam,
Phys. Rev. Lett. 107, 126804 (2011)



Broadband SPP focusing and WDM,
Nano Lett. 11, 4357 (2011)



Steering SPP from a point source,
Opt. Lett. 37, 5091 (2012)



Collimated “lossless” SPP beam,
Phys. Rev Lett. 110, 046807 (2013)

Outline

- Helmholtz Equation
- Gaussian beam
- Bessel beam
- Airy beam
- Mathieu and Weber beam
- Plasmonic counterpart

Nondiffracting beams

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Helmholtz Equation

- 电磁波波动方程

$$\nabla^2 \vec{B} - \frac{1}{c^2}\frac{\partial^2 \vec{B}}{\partial t^2} = 0 \qquad \nabla^2 \vec{E} - \frac{1}{c^2}\frac{\partial^2 \vec{E}}{\partial t^2} = 0$$

- 代入时谐电磁场

$$\vec{E}(\vec{x},t) = \vec{E}(\vec{x})\exp(-i\omega t)$$
$$\vec{B}(\vec{x},t) = \vec{B}(\vec{x})\exp(-i\omega t)$$

- 可得 赫姆霍兹方程：

$$\nabla^2 u + k^2 u = 0$$

$$k^2 = (\frac{\omega}{c})^2$$

u代表E和B

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亥姆霍兹方程： $\nabla^2\vec{E}+k^2\vec{E}=0$

最简单的解是： $\vec{E}\left(\vec{x}\right)=\vec{E}_0 e^{i\vec{k}\cdot\vec{x}}$ 平面电磁波

波形不随传播变化≠无衍射

因为它只是**wave**，不是**beam**

下面就来求解一个**beam**

(I) Gaussian beam

亥姆霍兹方程的波束解

我们考虑的波束能量分布具有轴对称性，中间场强最大，靠近边缘强度迅速衰减。在横截面上具有这种分布性质的最简单函数就是高斯函数：

$$e^{-\frac{x^2+y^2}{w^2}}$$

参数w表示光束的宽度
波束宽度通常还是z的函数

波幅通常也是z的函数，我们以***u(x,y,z)***代表电磁场任意直角分量，它可以具有如下形式

$$u(x,y,z)=g(z)e^{-f(z)(x^2+y^2)}e^{ikz}$$

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$$u(x,y,z)=g(z)e^{-f(z)(x^2+y^2)}e^{ikz}$$

式中 e^{ikz} 表示以来与z的主要因子，剩下的因子中还有对z的缓变函数g(z)和f(z)，

因子 $e^{-f(z)(x^2+y^2)}$ 是限制波束的空间宽度的因子。

因子g(z)主要表示波的振幅，同时也含有传播因子中与纯平面因子 e^{ikz} 偏离的部分。令

$$\phi(x,y,z)=g(z)e^{-f(z)(x^2+y^2)}$$

它满足z的缓变振幅近似。因此它对z的展开式中的高次项可以忽略。

根据亥姆霍兹方程 $\nabla^2 u + k^2 u = 0$

将 $u(x,y,z) = \phi(x,y,z)e^{ikz}$ 代入

得到：

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \left(\frac{\partial^2\phi}{\partial z^2} + 2ik\frac{\partial\phi}{\partial z} - k^2\phi\right) + k^2\phi = 0$$

忽略对z求导的高次项得到

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + 2ik\frac{\partial\phi}{\partial z} = 0$$

傍轴波动方程

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将ϕ的试探解形式代入

$$(x^2+y^2)[2gf^2-ikgf']-[2fg-ikg']=0$$

上式要对任意x, y都成立，必须两括号内都为零

$$\begin{cases} 2f^2 = ikf' & (1) \\ 2fg = ikg' & (2) \end{cases}$$

上式（1）的解形式为

$$f(z)=\frac{1}{A+\frac{2i}{k}z}$$

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对比（1）（2）式，可以看出**g(z)=f(z)×常数**

$$g(z)=\frac{u_0}{1+\frac{2i}{kA}z}$$

将**f(z)**变换，得到

$$f(z)=\frac{1}{A(1+\frac{4z^2}{k^2A^2})}(A-\frac{2i}{k}z)$$

令 $A=w_0^2$

$$w^2(z)=A(1+\frac{4z^2}{k^2A^2})=w_0^2[1+(\frac{2z}{kw_0^2})^2]$$

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则：
$$f(z)=\frac{1}{w^2(z)}(1-\frac{2iz}{kw_0^2})$$

那么高斯函数变为

$$e^{-f(z)(x^2+y^2)}=\exp\left[-\frac{x^2+y^2}{w^2(z)}(1-\frac{2iz}{kw_0^2})\right]$$

同样**g(z)** 可以写为

$$g(z)=\frac{u_0}{\sqrt{1+(\frac{2z}{kw_0^2})^2}}e^{-i\varphi}=u_0\frac{w_0}{w}e^{-i\varphi}$$

其中 $\varphi=\arctan(\frac{2z}{kw_0^2})$

最终得到光束场强函数

$$u(x,y,z)=u_0\frac{w_0}{w}e^{-\frac{x^2+y^2}{w^2}}e^{-i\Phi}$$

其中

$$\Phi=kz+\frac{k(x^2+y^2)}{2z\left[1+(\frac{kw_0^2}{2z})^2\right]}-\varphi$$

$$w^2(z)=w_0^2[1+(\frac{2z}{kw_0^2})^2]$$

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高斯光束的传播特性

$$u(x,y,z)=u_0\frac{w_0}{w}e^{-\frac{x^2+y^2}{w^2}}e^{-i\Phi}$$

振幅　　相因子

$e^{-\frac{x^2+y^2}{w^2}}$ 限制波束宽度

$$w^2(z)=w_0^2[1+(\frac{2z}{kw_0^2})^2]$$

波束宽度由w(z)代表，在z=0处波束具有最小宽度，称为光束腰部——束腰。

$u_0\frac{w_0}{w}$ z轴上的振幅，u_0是束腰位置的振幅。

$$\Phi = kz + \frac{k(x^2 + y^2)}{2z\left[1 + (\frac{kw_0^2}{2z})^2\right]} - \varphi$$

光束波阵面是等相位面，由相位Φ=常数确定。

当z=0时，Φ=0，说明z=0平面是一个波阵面，即光束腰部波阵面与z轴垂直。

当远离束腰部位 $z >> kw_0^2$ $\varphi \to \pi/2$

$$z + \frac{x^2 + y^2}{2z} = 常数$$

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再由 $$z^2 >> x^2 + y^2$$

$$(1+\frac{x^2+y^2}{z^2})^{\frac{1}{2}} \approx 1+\frac{x^2+y^2}{2z^2}$$

所以等相位面方程可写为:

$$z(1+\frac{x^2+y^2}{z^2})^{\frac{1}{2}} \approx 常数$$

即 $$r = (x^2 + y^2 + z^2)^{\frac{1}{2}} \approx 常数$$

因此，在远处波阵面变为以束腰中心为球心的一个球面。总的波阵面就是从腰部的平面逐渐过渡到远处的球面形状。

另外，在远处 $z >> kw_0^2$

$$w(z) = w_0^2[1+(\frac{2z}{kw_0^2})^2] \approx \frac{2z}{kw_0^2}$$

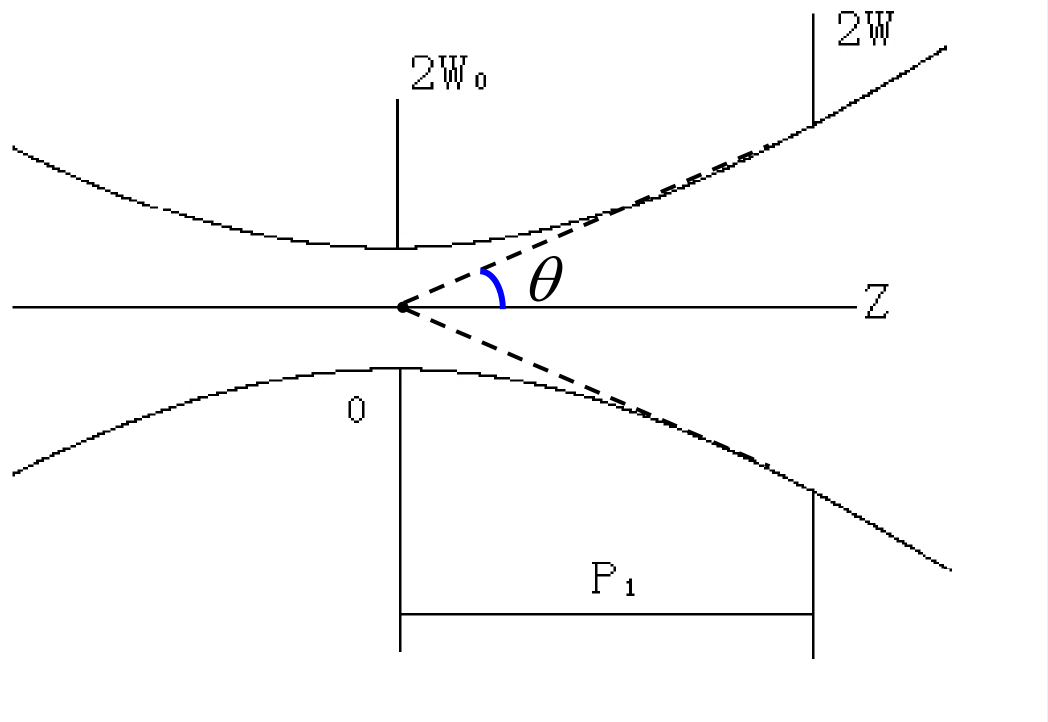
波束发散角由tan*θ*=*w*/z确定，所以

$$\tan\theta \approx \frac{2}{kw_0^2}$$

对应一给定波长的电磁波，当w_0愈小时，发散角愈大。因此，要求良好的聚焦效果，发散角必须足够大；如果要求良好定向，则光束宽度不能太小。

$$\Delta k_\perp \cdot w_0 \approx O(1)$$

高斯光束示意图



光束在传播中有发散，明显的衍射效应

Q1：是否存在不衍射的光束？

(II) Bessel beam

Helmhotz Equation $\nabla^2 u + k^2 u = 0$

在柱坐标下变为

$$\frac{1}{r}\frac{\partial u}{\partial r}(\frac{1}{r}\frac{\partial u}{\partial r}) + \frac{1}{r^2}\frac{\partial^2 u}{\partial \theta^2} + \frac{\partial^2 u}{\partial z^2} + k^2 u = 0$$

令$u(r,\theta,z) = v(r,\theta)Z(z)$,代入方程:

$$Z[\frac{1}{r}\frac{\partial}{\partial r}(\frac{1}{r}\frac{\partial v}{\partial r}) + \frac{1}{r^2}\frac{\partial^2 v}{\partial \theta^2} + k^2 v] = -v\frac{d^2 Z}{dz^2}$$

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作分离变量，引入常数λ，得到：

$$\frac{1}{r}\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial v}{\partial r}\right)+\frac{1}{r^2}\frac{\partial^2 v}{\partial \theta^2}+(k^2-\lambda)v=0$$

$$\frac{d^2 Z}{dz^2}+\lambda Z=0$$

接着令$v(r,\theta)=R(r)\Phi(\theta)$,代入得到：

$$\frac{r^2}{R}\left[\frac{1}{r}\frac{d}{dr}\left(r\frac{dR}{dr}\right)+(k^2-\lambda)R\right]=-\frac{1}{\Phi}\frac{d^2\Phi}{d\theta^2}$$

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最终得到三个分离变量微分方程:

$$\frac{1}{r}\frac{d}{dr}(r\frac{dR}{dr})+(k^2-\lambda-\frac{\mu}{r^2})R=0$$

$$\frac{d^2\Phi}{d\theta^2}+\mu\Phi=0 \qquad \Phi_m(\theta)=\begin{cases}\cos(m\theta)\\ \sin(m\theta)\end{cases} \text{或} \begin{cases}\exp(im\theta)\\ \exp(-im\theta)\end{cases}$$

$$\frac{d^2Z}{dz^2}+\lambda Z=0 \qquad Z_\lambda(z)=\begin{cases}\cos(k_z z)\\ \sin(k_z z)\end{cases} \text{或} \begin{cases}\exp(ik_z z)\\ \exp(-ik_z z)\end{cases}$$

这里$\mu=m^2,\lambda=k_z^2$。

令$k_r^2=k^2-k_z^2=k^2-\lambda$。此时方程（1）变为

$$\frac{1}{r}\frac{d}{dr}(r\frac{dR}{dr})+(k_r^2-\frac{m^2}{r^2})R=0$$

Bessel 方程

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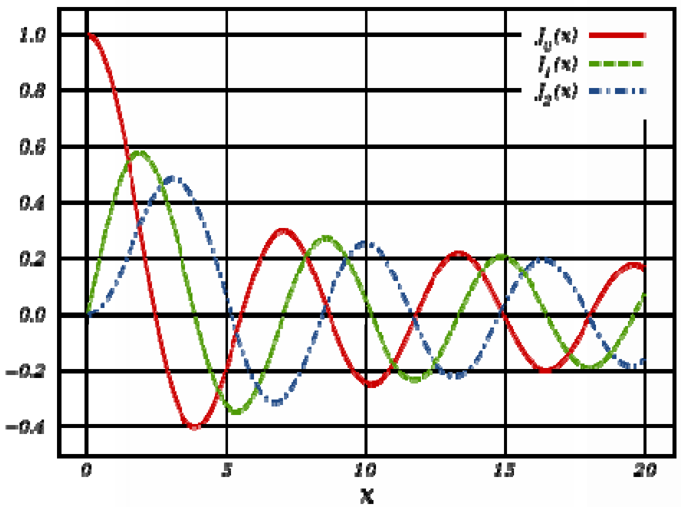
因此我们得到径向函数的通解

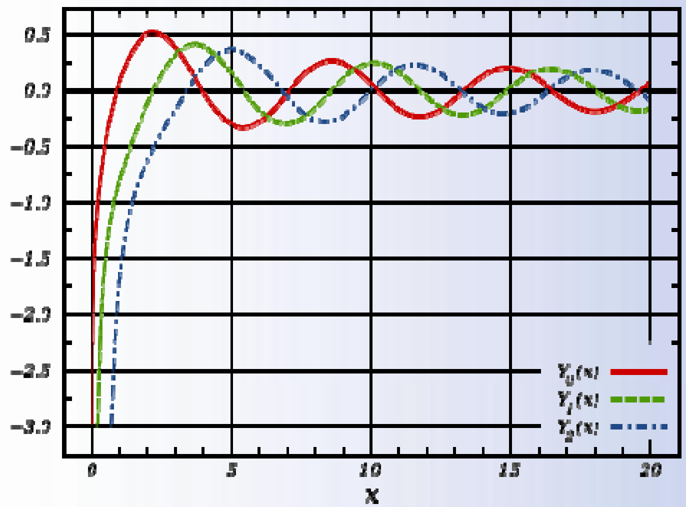
$$R(r) = CJ_m(k_r r) + DN_m(k_r r)$$

由边界R(0)有限值，得到D=0。

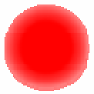
所以最终的径向解就是Bessel函数**J_m(kr)**形式，

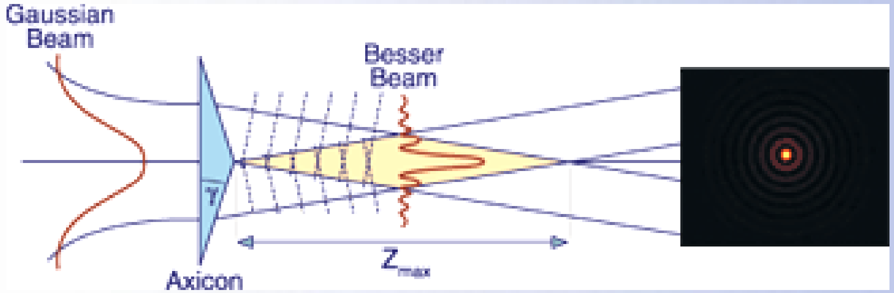
而旋转切向则为振荡解，振荡波矢**m**决定J的阶数！

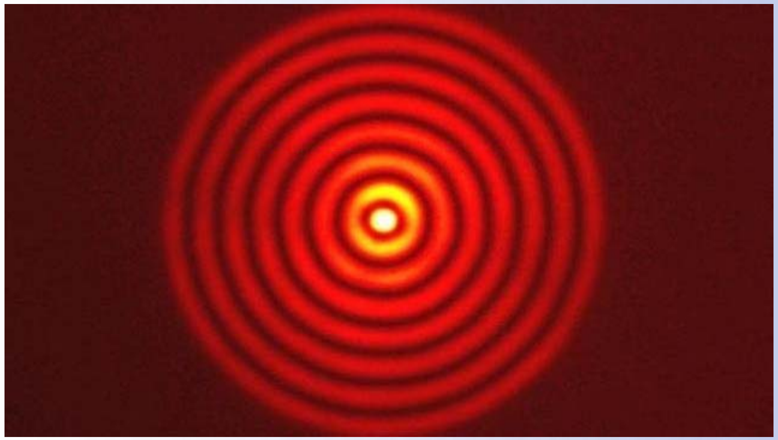


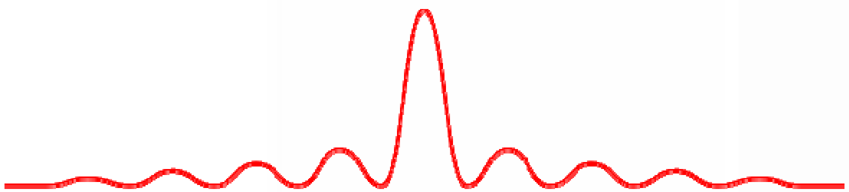


零阶Bessel beam （m=0）









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PHYSICAL REVIEW
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Diffraction-Free Beams

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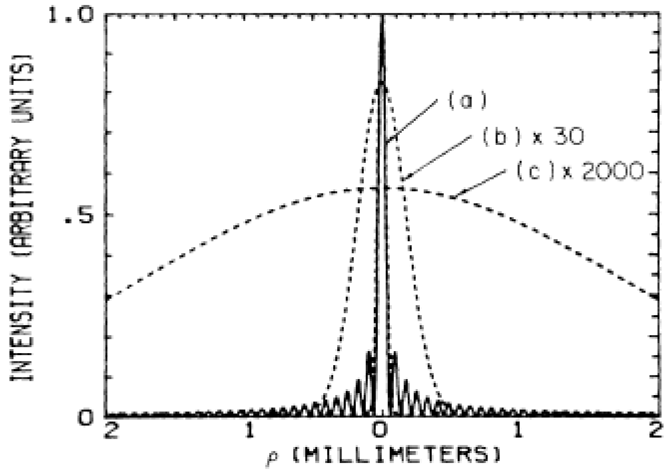

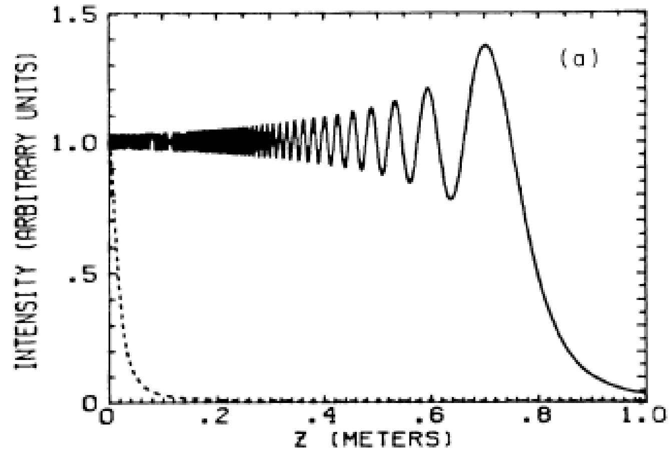

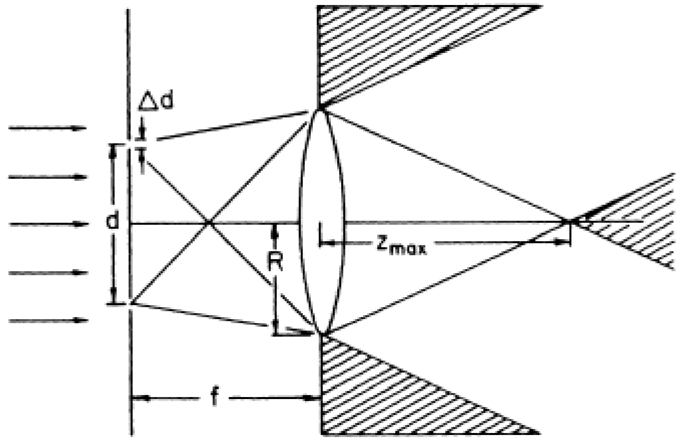

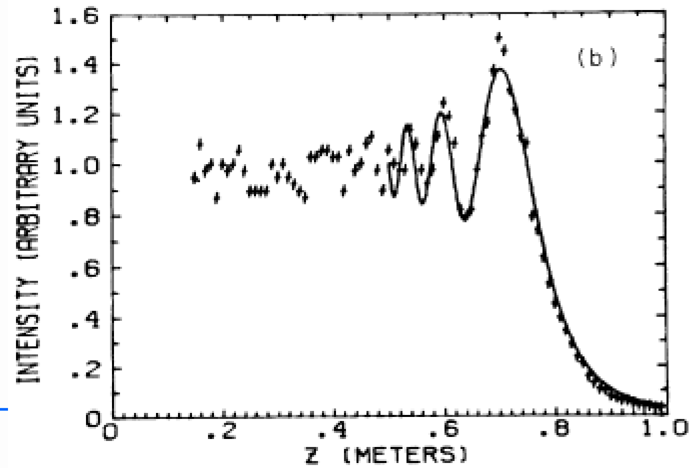

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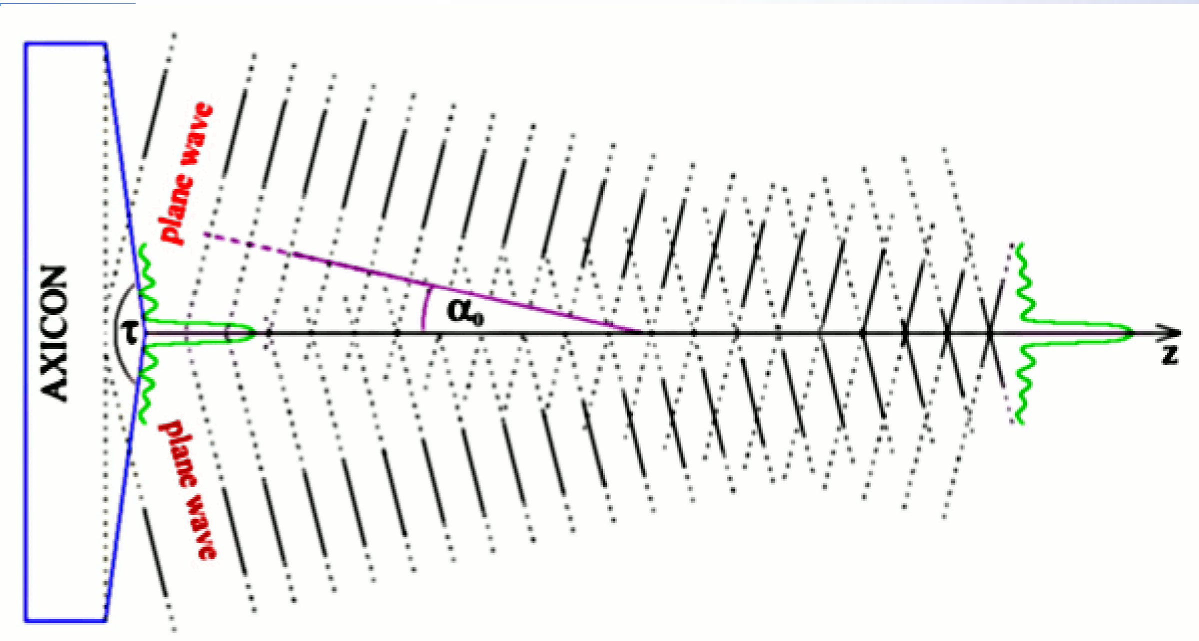

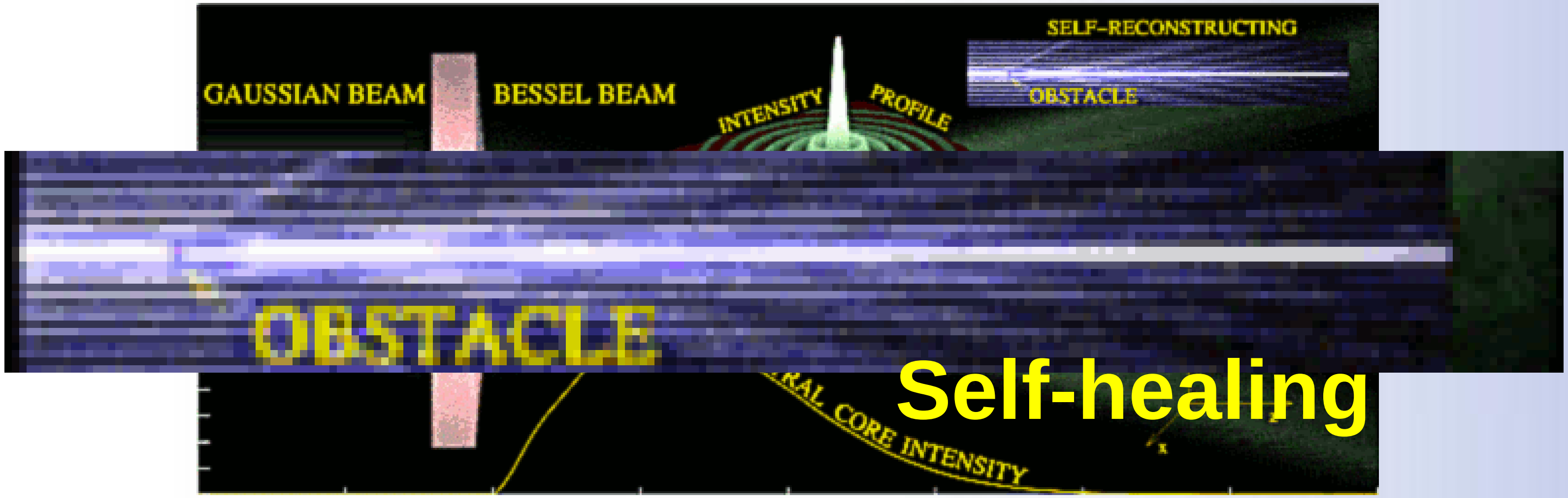

Self-healing

http://www.isibrno.cz/omitec/index.php?action=bessintr.html

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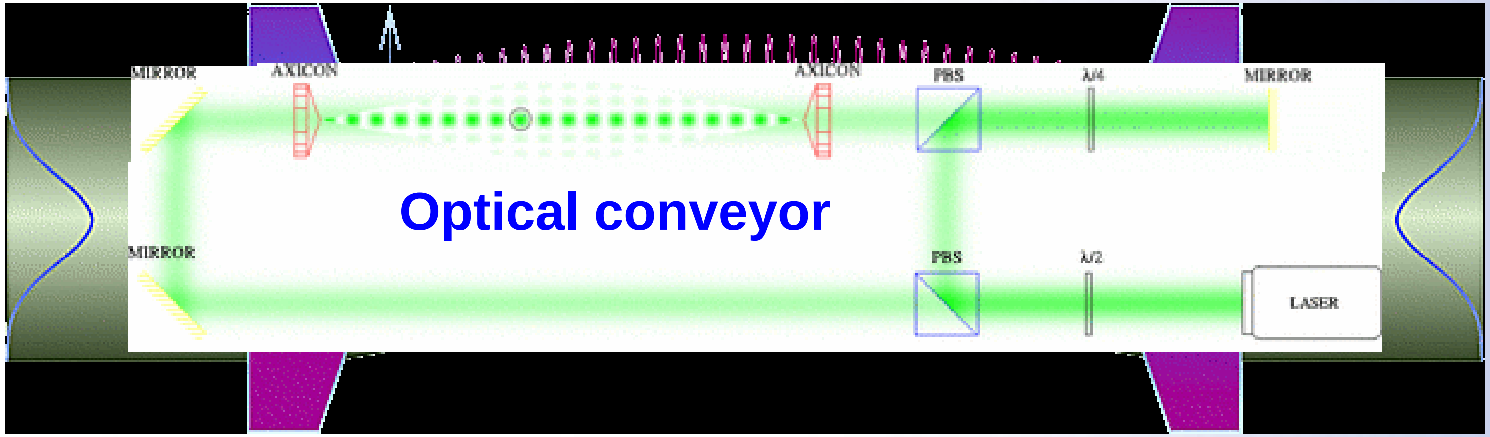
Q2：是否存在弯曲的 nondiffracting beam?



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(III) Airy beam

- 回到Cartesian傍轴波动方程

$$\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}+2ik\frac{\partial\phi}{\partial z}=0$$

- 如果考虑场在y方向均匀，即无波动，则方程变为二维傍轴方程，如下

$$\frac{\partial^2\phi}{\partial x^2}+2ik\frac{\partial\phi}{\partial z}=0$$

形式一致！

- 对照薛定谔方程

$$-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2}=i\hbar\frac{\partial\psi}{\partial t}$$

如何求解？

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Airy 函数

*Airy*方程：$y''-xy=0$

$y=\mathrm{Ai}(x)$是方程的一支解。

$$\mathrm{Ai}(x)=\frac{1}{\pi}\int_0^\infty \cos\left(\frac{t^3}{3}+xt\right)dt$$

还有一支

$$\mathrm{Bi}(x)=\frac{1}{\pi}\int_0^\infty\left[\exp\left(-\frac{t^3}{3}+xt\right)+\sin\left(\frac{t^3}{3}+xt\right)\right]dt$$

真正的通解：

$$y=C_1\,\mathrm{Ai}(x)+C_2\,\mathrm{Bi}(x)$$

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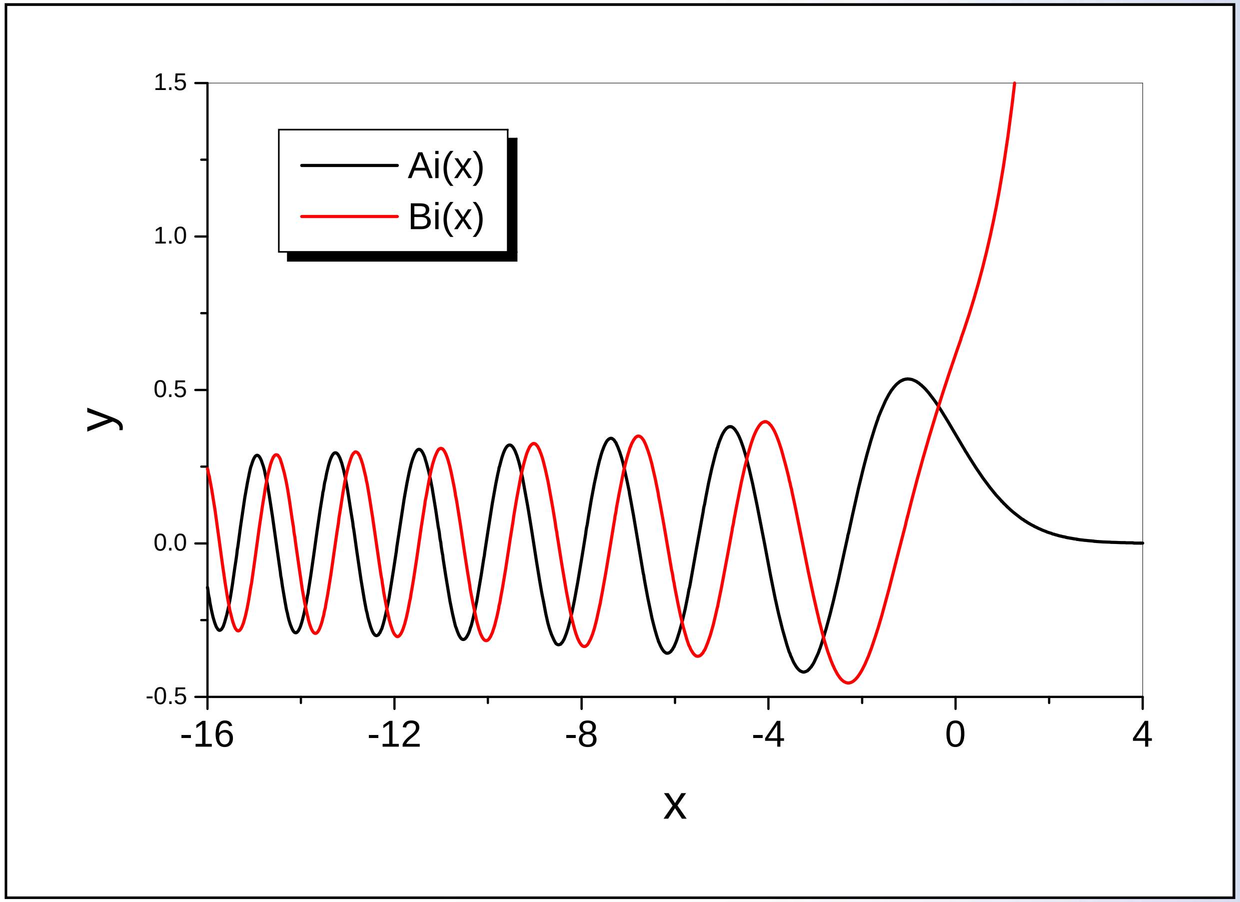
Ai(x) Bi(x) 函数图象



Ai(x)函数具体形式

$$Airy方程：\frac{d^2Ai(x)}{dx^2} - xAi(x) = 0$$

对其做变量变换 $\xi = x^{3/2}, w(\xi) = Ai(x)/\sqrt{x}$

得到：

$$\frac{d^2w}{d\xi^2} + \frac{1}{\xi}\frac{dw}{d\xi} - (\frac{1}{3})^2(4 + \frac{1}{\xi^2})w = 0$$

虚宗量贝塞尔方程

$$\mathrm{Ai}(x) = \begin{cases} \frac{1}{\pi}\sqrt{\frac{x}{3}}\mathrm{K}_{1/3}\left(\frac{2}{3}x^{\frac{3}{2}}\right), & (x>0) \\ \frac{\sqrt{-x}}{3}\left[\mathrm{J}_{1/3}\left(\frac{2}{3}(-x)^{\frac{3}{2}}\right) + \mathrm{J}_{-1/3}\left(\frac{2}{3}(-x)^{\frac{3}{2}}\right)\right], & (x<0) \end{cases}$$

贝塞尔函数的马甲

如何根据Ai(x)求薛定谔方程：$\frac{\partial^2\phi}{\partial x^2}+2ik\frac{\partial\phi}{\partial z}=0$

不失一般性令$\phi=\mathrm{Ai}(f_1)\exp(f_2)$，其中$f_1$和$f_2$是$x,z$的函数。

然后求出$\frac{\partial\phi}{\partial z}$、$\frac{\partial^2\phi}{\partial x^2}$的具体形式，代入波动方程，并利用：

$$\mathrm{Ai}''(x)=x\,\mathrm{Ai}(x)$$

最后对比$\mathrm{Ai}(x)$和$\mathrm{Ai}'(x)$前面的系数，可得：

$$\begin{cases}\frac{\partial^2 f_1}{\partial x^2}+2\frac{\partial f_1}{\partial x}\frac{\partial f_2}{\partial x}=-2ik\frac{\partial f_1}{\partial z}\\ \left(\frac{\partial f_2}{\partial x}\right)^2+\frac{\partial^2 f_2}{\partial x^2}+f_1\left(\frac{\partial f_1}{\partial x}\right)^2=-2ik\frac{\partial f_2}{\partial z}\end{cases}$$

考虑无衍射形式的解，这要求$f_1 = ax + f_3(z)$，其中f_3仅是z的函数。代入上述方程组，然后分离变量，并考虑初值条件，最后可解得：

$$f_3(z) = -\frac{a^4}{4k^2}z^2,$$

$$f_1(x,z) = ax - \frac{a^4 z^2}{4k^2},$$

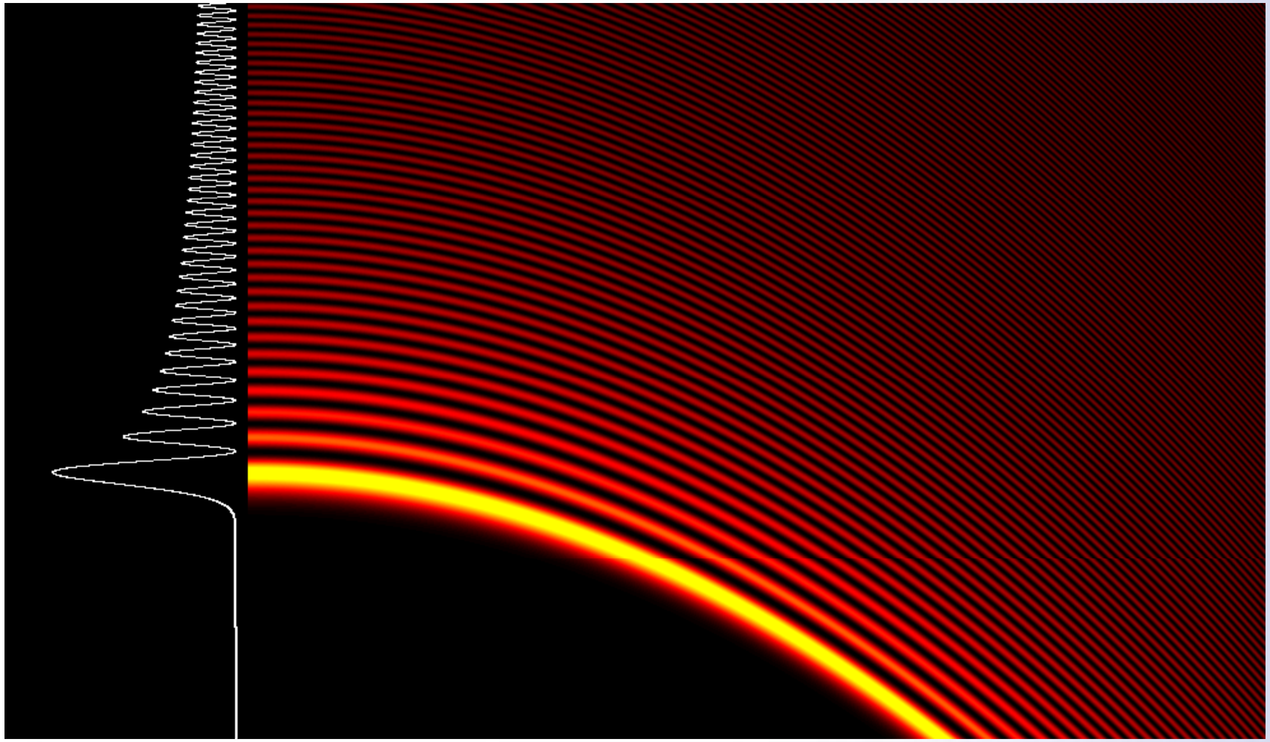
$$f_2(x,z) = i\frac{a^6 z^3}{12k^3} - i\frac{a^3 xz}{2k}.$$

将f_1和f_2代入ϕ的表达式即可得到最后结果。

$\phi(x,0) = \mathrm{Ai}(ax)$初值条件下得到非衍射严格解：

$$\phi(x,z) = \mathrm{Ai}\left(ax - \frac{a^4 z^2}{4k^2}\right)\exp\left(i\frac{a^6 z^3}{12k^3} - i\frac{a^3 xz}{2k}\right)$$

Airy beam图象



不衍射，不发散，
自弯曲，自加速，自修复

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Nonspreading wave packets

$$\psi(x,0) \approx \frac{1}{\sqrt{\pi}} \left(\frac{\hbar^{2/3}}{-Bx} \right)^{1/4} \sin[\pi/4 + 2(-Bx)^{3/2}/3\hbar]$$

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(Received 30 June 1978; accepted 12 September 1978)

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Observation of Accelerating Airy Be

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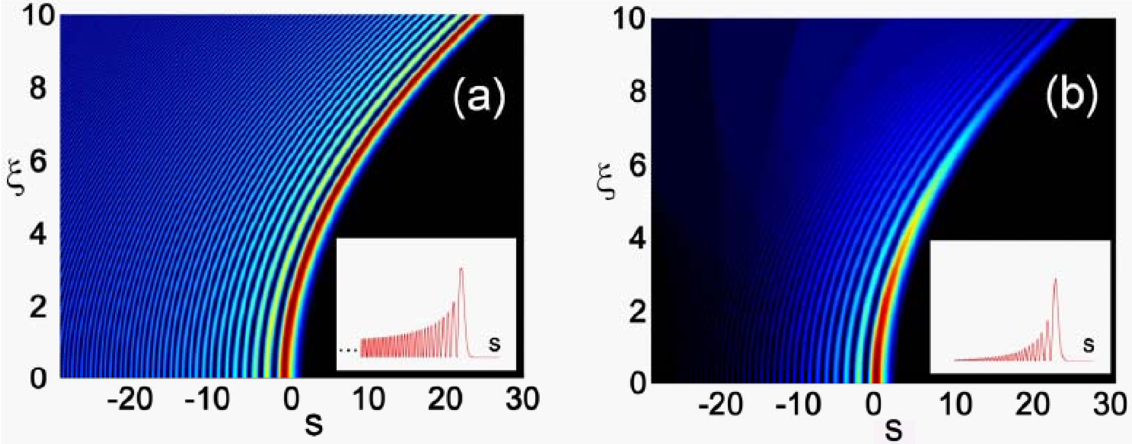
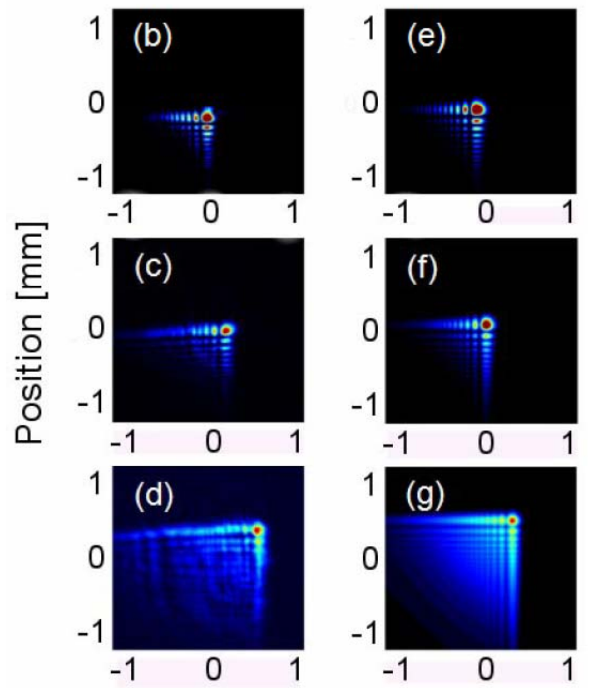




Infinite → finite

$$i\frac{\partial \phi}{\partial \xi}+\frac{1}{2}\frac{\partial^2 \phi}{\partial s^2}=0,$$

$$\phi(\xi, s)=\mathrm{Ai}(s-(\xi/2)^2)\exp(i(s\xi/2)-i(\xi^3/12)).$$

有限能量 $\phi(0, s)=\mathrm{Ai}\,(s)\exp(as)$

$$\phi(\xi, s)=\mathrm{Ai}\,(s-(\xi/2)^2+ia\xi)\exp(as-(a\xi^2/2) - i(\xi^3/12)+i(a^2\xi/2)+i(s\xi/2)).$$

Fourier Transformation

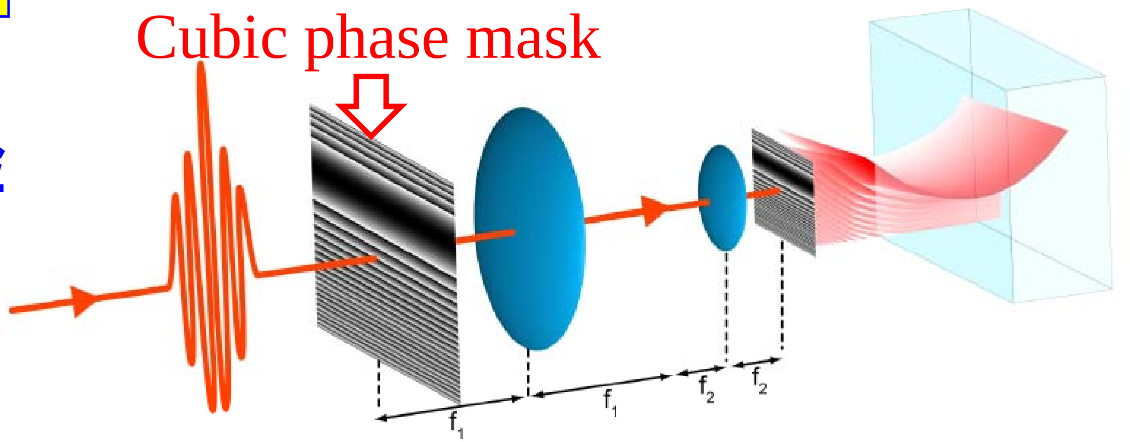
$$\Phi(k)\propto \exp(-ak^2)\exp(ik^3/3)$$

高斯光束

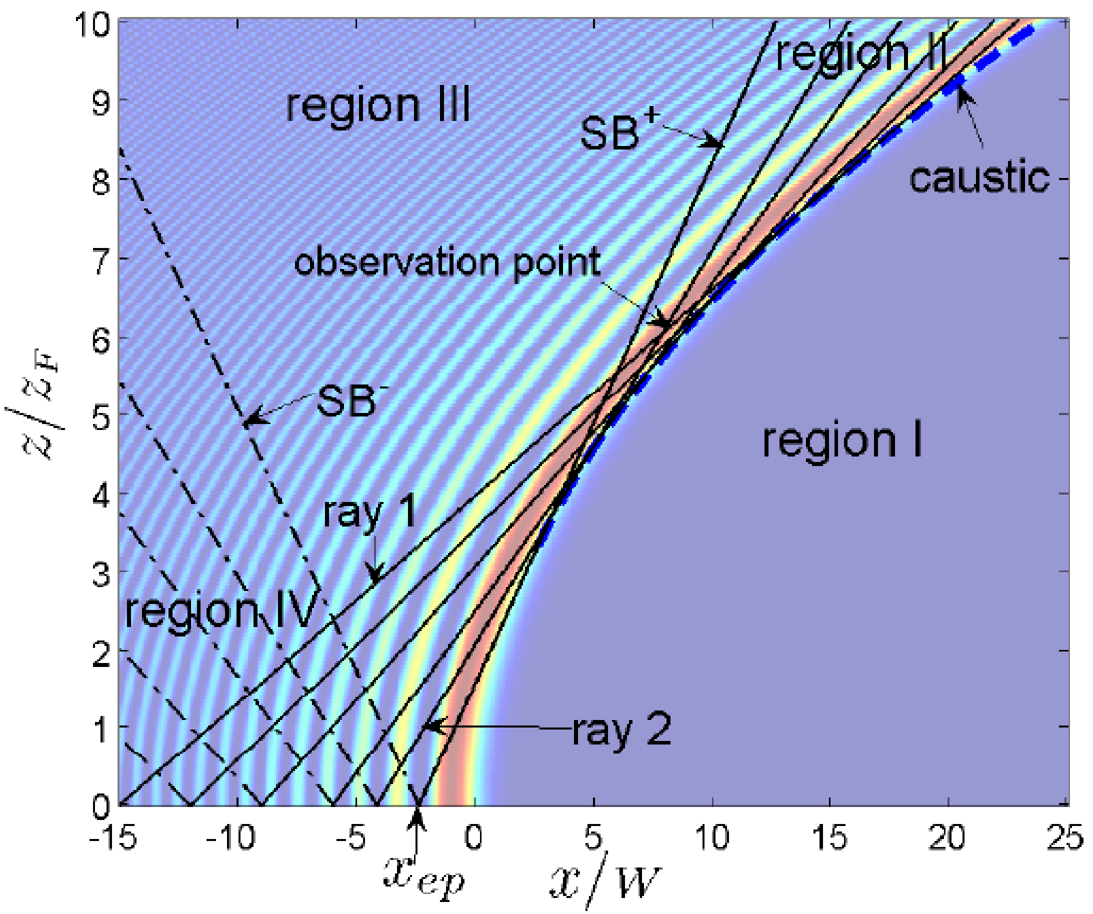
附加相位调制

Cubic phase mask

实验



Geometric optics illustration



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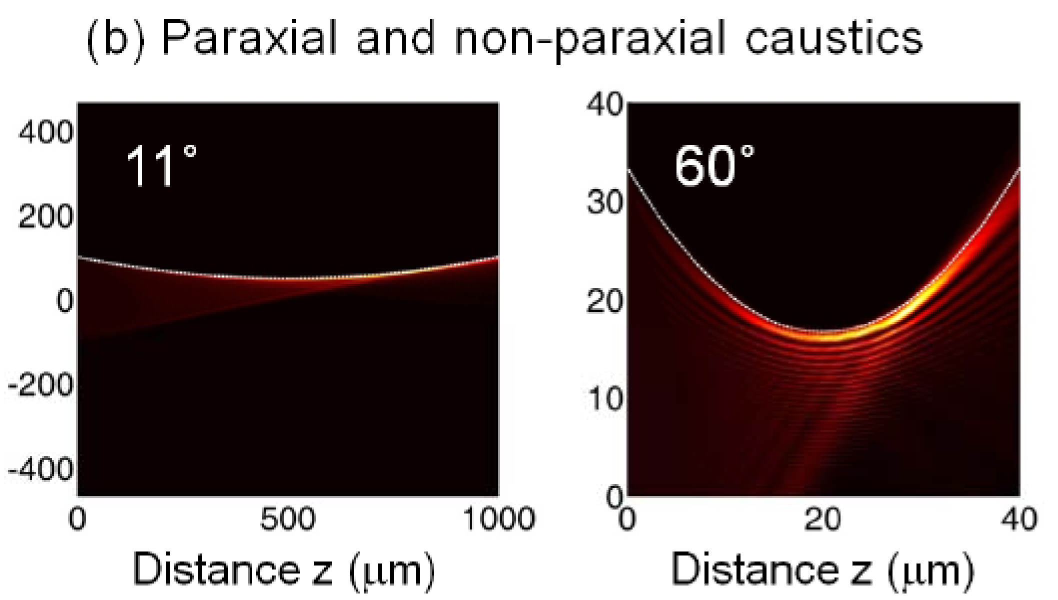
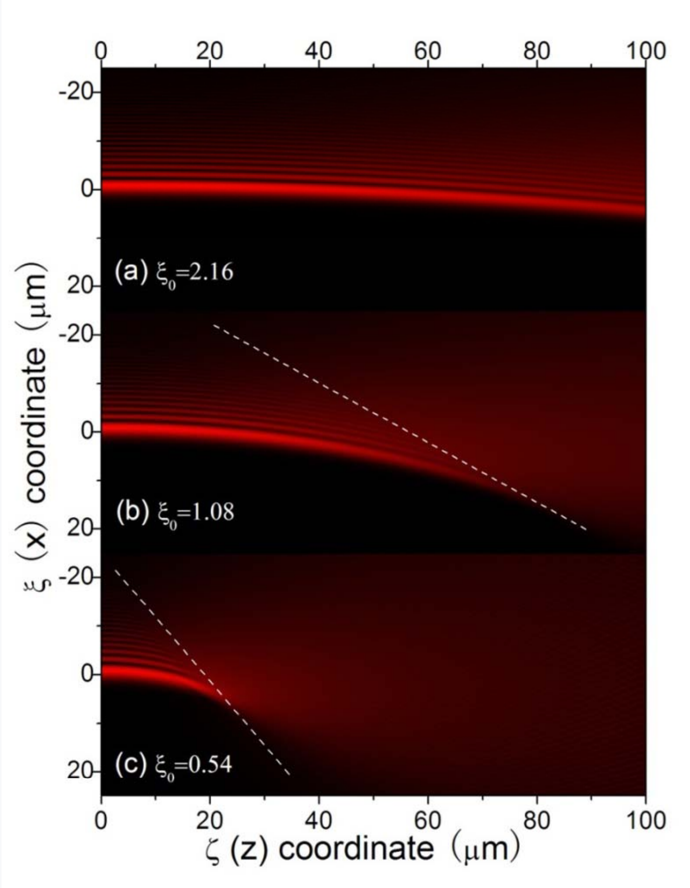
傍轴问题（paraxial）

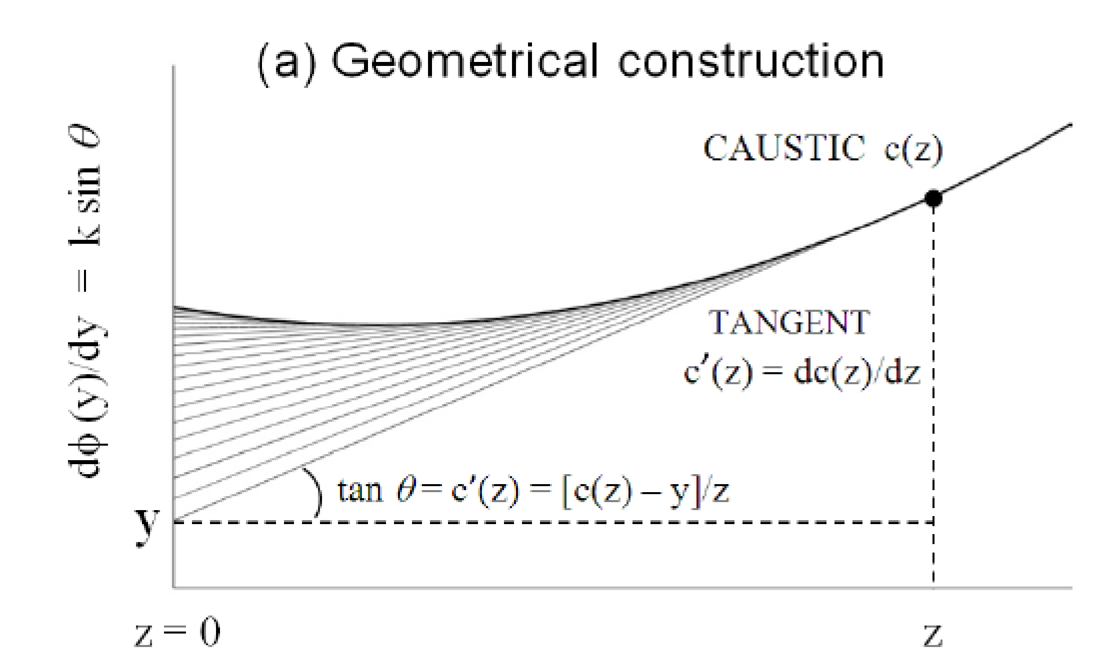
$$\psi(x) = -\frac{2}{3}\left(-\frac{\xi}{\xi_0}\right)^{3/2} - \frac{\pi}{4} - k\frac{\xi\sin\theta}{\cos(\theta-\theta_\xi)}$$





?

Arbitrary caustic beam



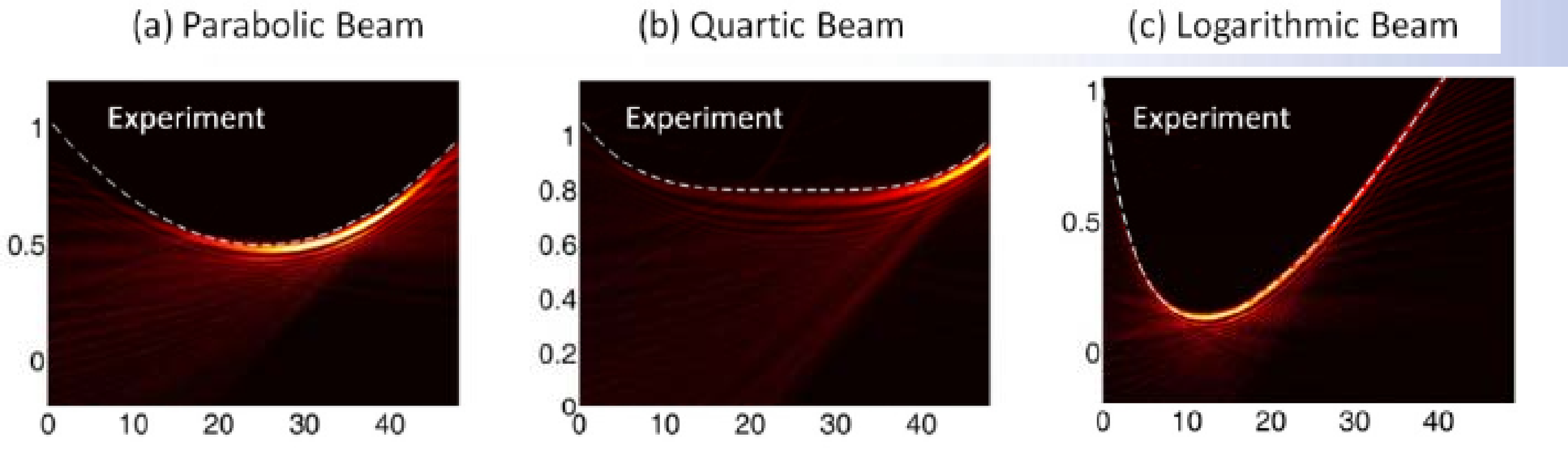
$$\frac{d\phi(y)}{dy} = k\sin\theta = \frac{k\,c'(z)}{\sqrt{1+[c'(z)]^2}}$$

Paraxial approximation: $\tan\theta \approx \sin\theta \approx \theta$

Airy beam

Table 1. In the Paraxial Approximation, this Table gives the Calculated Phase for Desired Acceleration Profiles as Shown.

Acceleration profile	Applied phase
Parabolic: $c(z) = az^2$	$\phi(y) = -4/3\, a^{1/2}\, k\, y^{3/2}$
Quartic: $c(z) = az^4$	$\phi(y) = -16/21\, (3a)^{1/4}\, k\, y^{7/4}$
Logarithmic: $c(z) = a \ln(bz)$	$\phi(y) = e^{-1} a^2 b\, k\, (1-\exp[-y/a])$
Polynomial: $c(z) = az^n$ (for n even)	$\phi(y) = kn^2 y^2 \frac{[a(1-n)/y]^{1/n}}{(2n-1)(1-n)}$



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Nonparaxial $\stackrel{?}{=}$ nondiffracting

数学上：Airy 函数解是Helmhotz方程傍轴近似下的严格解。

实验上：当caustic beam角度变大后，beam明显偏离原来的profile。

Q3：是否存在 nonparaxial nondiffracting beam?

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(III) Mathieu beam and Weber beam

- 回到最原始波动方程

$$\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial y^2}+\frac{\partial^2\phi}{\partial z^2}+\frac{1}{c^2}\frac{\partial\phi}{\partial t}=0$$

- 考虑场在y方向均匀，则变为二维Helmhotz方程

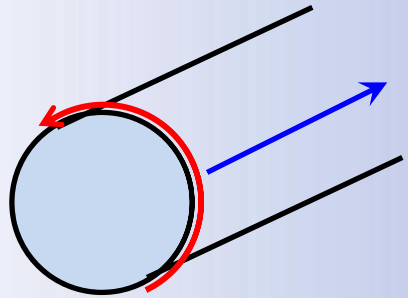
$$\frac{\partial^2\phi}{\partial x^2}+\frac{\partial^2\phi}{\partial z^2}+\frac{1}{c^2}\frac{\partial\phi}{\partial t}=0$$

- 分离变量令 $\phi=U(r)\exp(i\alpha\theta-i\omega t)$
  则径向函数满足

$$\frac{1}{r}\frac{\partial}{\partial r}(r\frac{\partial U}{\partial r})+(k^2-\frac{\alpha^2}{r^2})U=0$$

标准的Bessel方程

• 如此得到径向不衍射解



$$U(r) = J_\alpha(kr)$$

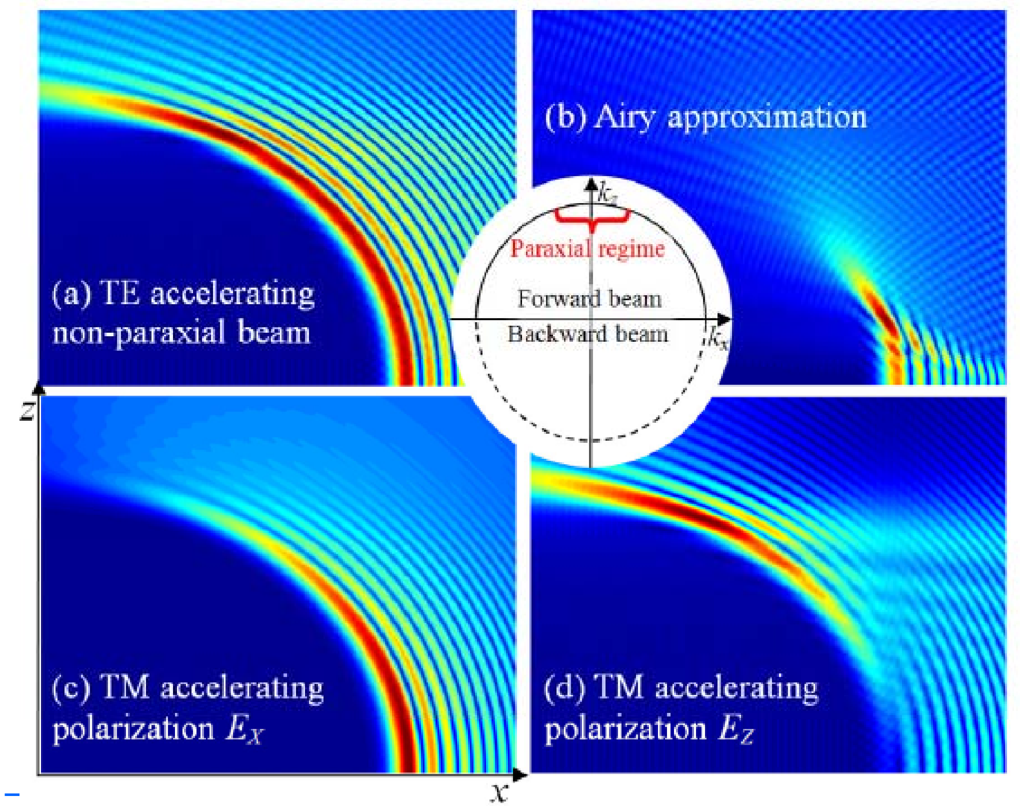
$$\phi = J_\alpha(kr)\exp(i\alpha\theta - i\omega t)$$

注意：α表示方位角向θ的行波波数，在求Bessel光束时候我们用零阶

旨z轴传播$k_z \neq 0$。

=0），从而 α≠0，得到高阶

的不衍射弯曲波。



这里α=100（高阶贝塞尔函数）
这时beam弯曲接近90度，
大大突破了paraxial的限制！

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刚才的结果是在柱坐标下完成，其实可以进一步推广到椭圆坐标、抛物坐标等任意曲线坐标系下：

椭圆坐标系

$$\begin{cases} x = h\sinh\xi\sin\eta \\ z = h\cosh\xi\cos\eta \end{cases}$$

$\xi \in [0,\infty)$对应于“径向”

$\eta \in [0,2\pi)$对应于“方位角”

$h = \sqrt{|a^2 - b^2|}$

$$\frac{d^2R(\xi)}{d\xi^2} - (\beta - 2q\cosh 2\xi)R(\xi) = 0$$

$$\frac{d^2\Theta(\eta)}{d\xi^2} - (\beta - 2q\cosh 2\xi)\Theta(\eta) = 0$$

$$M(\xi,q) = R_m(\xi,q)(ce_m(\eta;q) - ise_m(\eta;q))$$

径向Mathieu函数

角向Mathieu函数

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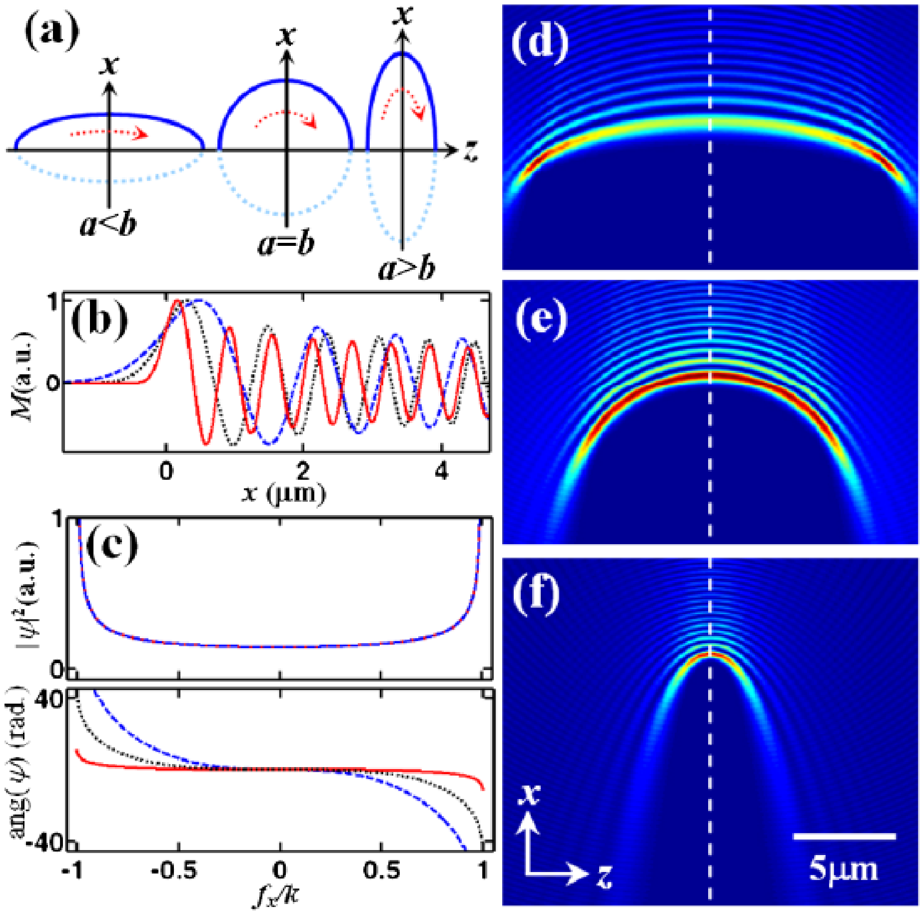
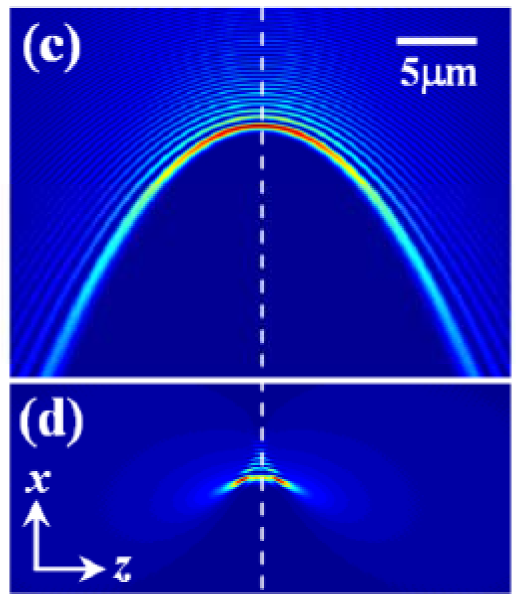
Mathieu beam



Parabolic coordinate

$$\frac{d^2\Phi(\sigma)}{d\sigma^2} + (k^2\sigma^2 + 2k\gamma)\Phi(\sigma) = 0,$$

$$\frac{d^2\vartheta(\tau)}{d\tau^2} + (k^2\tau^2 - 2k\gamma)\vartheta(\tau) = 0,$$



Weber beam

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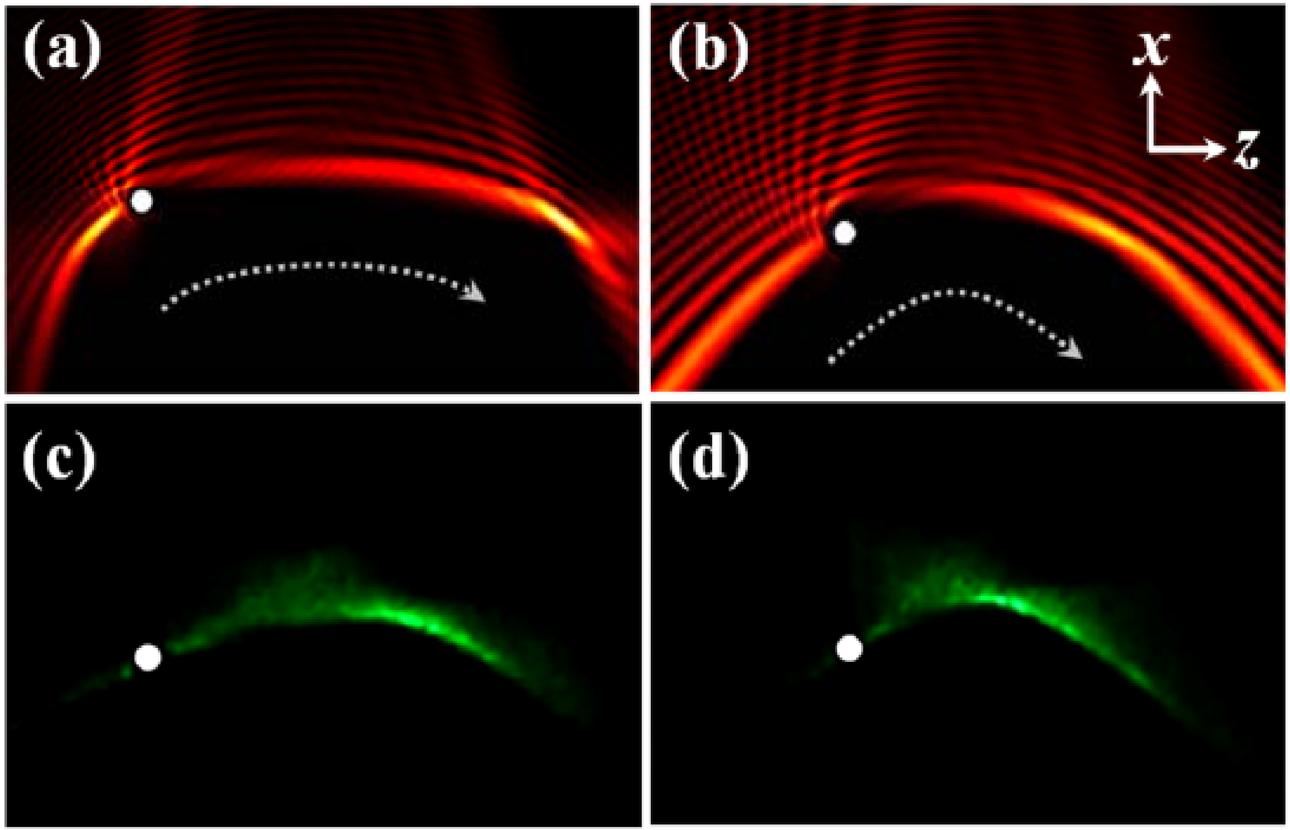
Self-healing property



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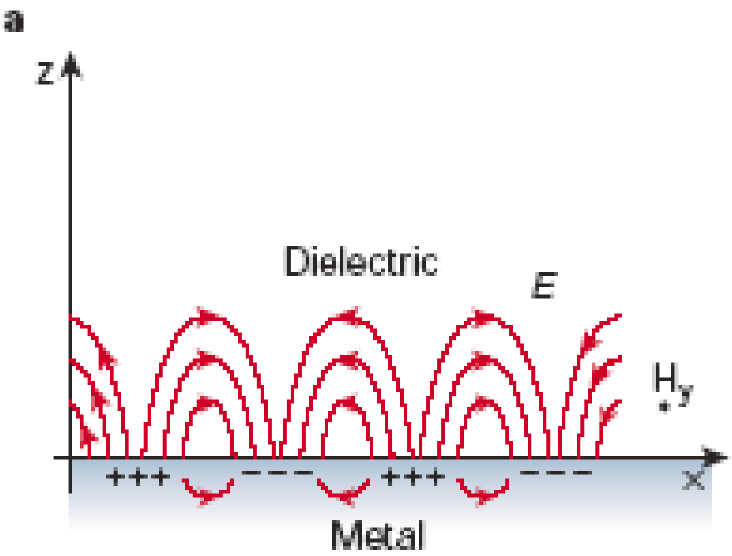
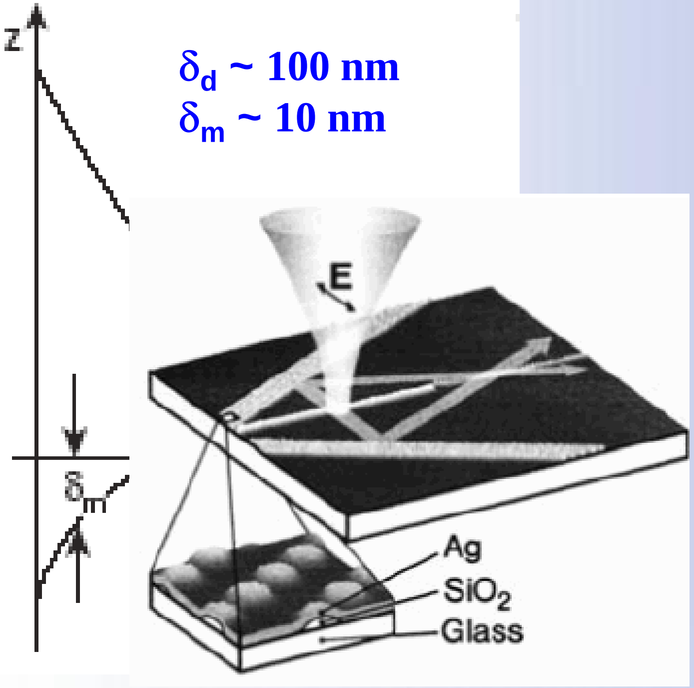
(IV) Plasmon counterparts

Two dimensional nature of SPP





δ_d ~ 100 nm
δ_m ~ 10 nm

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Nanjing University

Airy plasmon: a nondiffracting surface wave

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Received March 1, 2010; accepted May 17, 2010;
posted June 2, 2010 (Doc. ID 124913); published June 11, 2010

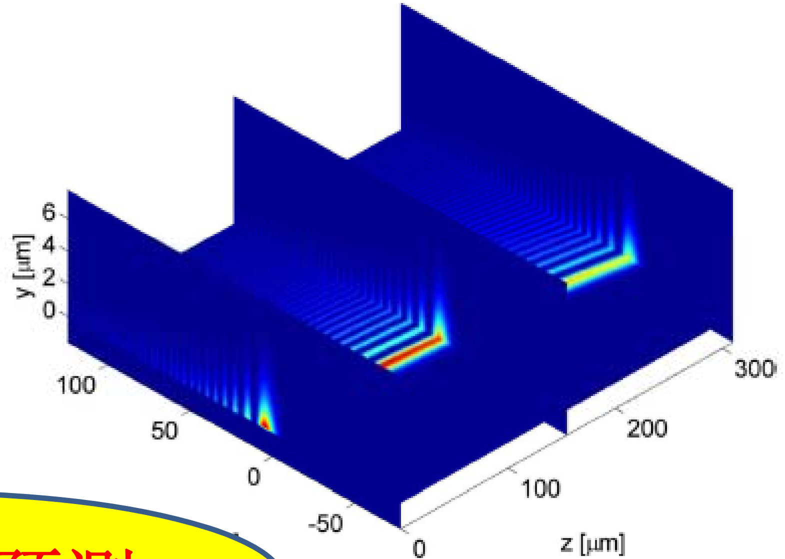
针对SPP的TM场的方程

$$\nabla^2 E_{dy} + k_0^2 \varepsilon_d E_{dy} = 0.$$

$$\frac{\partial^2 A}{\partial x^2} + 2ik_z \frac{\partial A}{\partial z} = 0.$$

很容易也可得到Airy函数的解

$$A(x,z) = Ai\left[\frac{x}{x_0} - \left(\frac{z}{2k_z x_0^2}\right)^2 + i\frac{az}{k_z x_0^2}\right] \times \exp\left[i\left(\frac{x + a^2 x_0}{2x_0}\frac{z}{k_z x_0^2} - \frac{1}{12}\left(\frac{z}{k_z x_0^2}\right)^3\right)\right] \times \exp\left[a\frac{x}{x_0} - \frac{a}{2}\left(\frac{z}{k_z x_0^2}\right)^2\right].$$

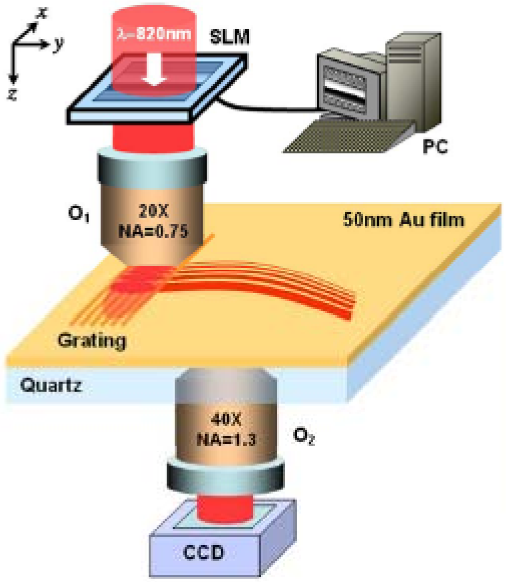


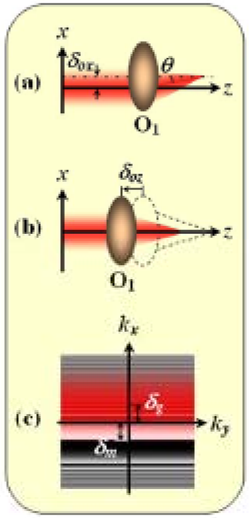
Only理论预测

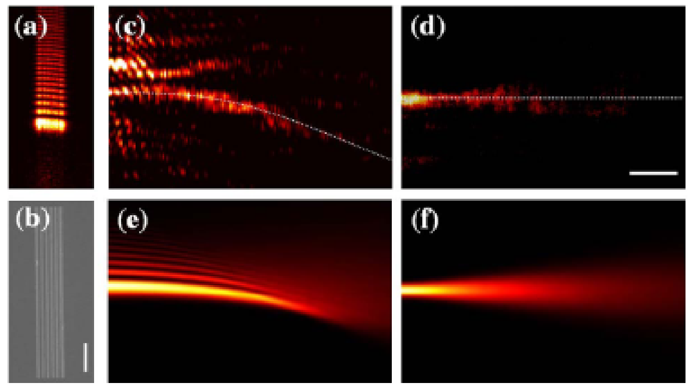
August 15, 2011 / Vol. 36, No. 16 / OPTICS LETTERS

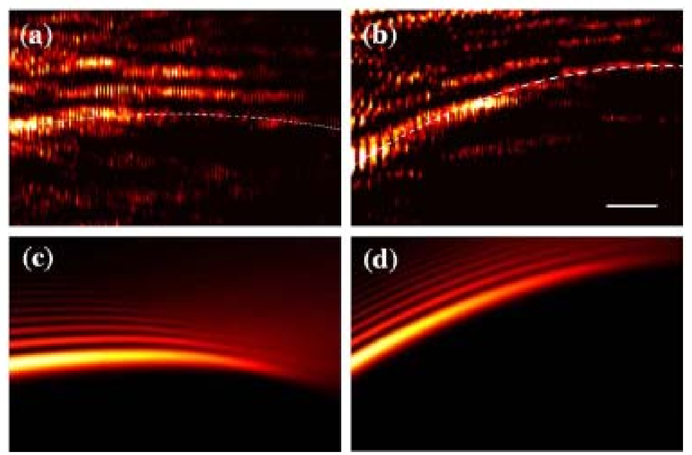
Plasmonic Airy beams with dynamically controlled trajectories

Peng Zhang,[1,2,†] Sheng Wang,[1,†] Yongmin Liu,[1,†] Xiaobo Yin,[1,3] Changgui Lu,[1] Zhigang Chen,[2] and Xiang Zhang[1,3,*]







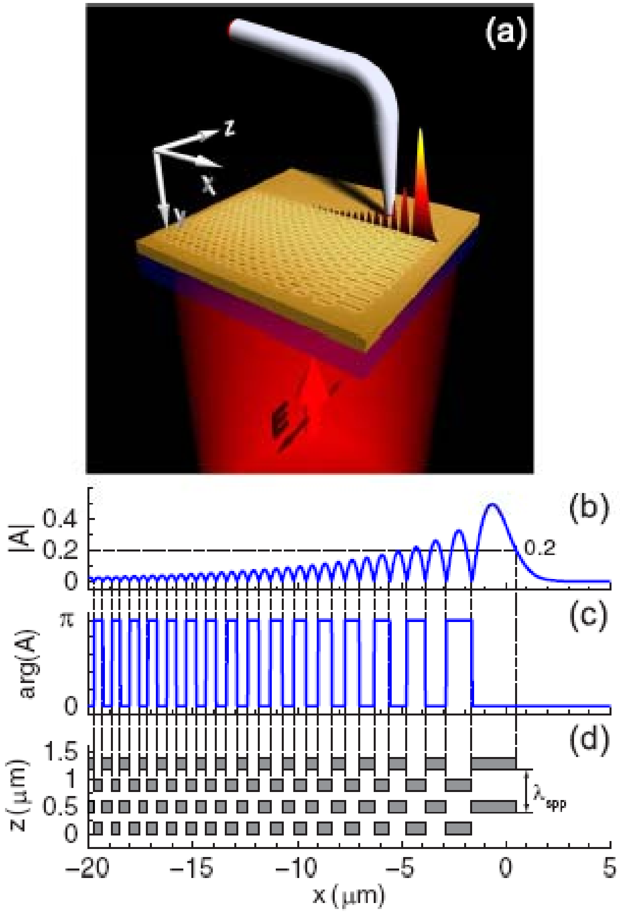


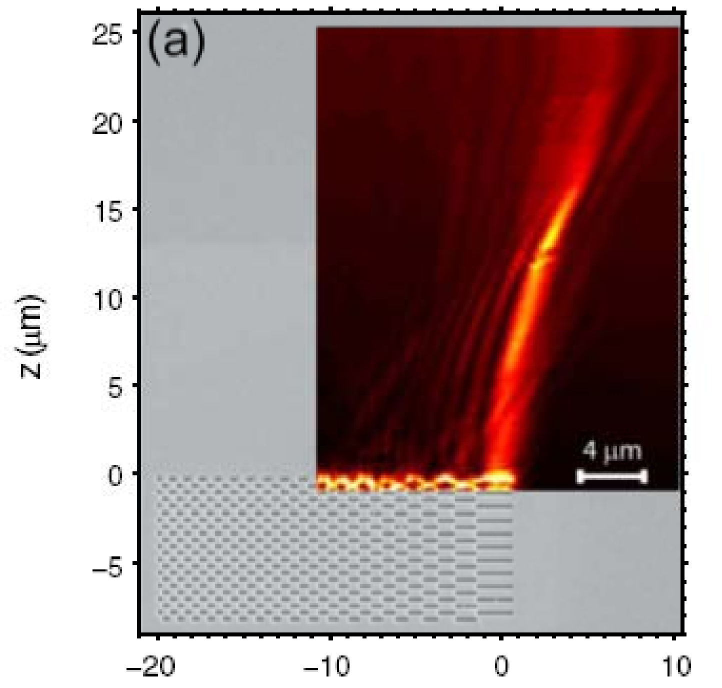
Coupling a well generated Airy beam to SPP

Selected for a Viewpoint in *Physics*
PRL **107**, 116802 (2011) PHYSICAL REVIEW LETTERS week ending 9 SEPTEMBER 2011

Generation and Near-Field Imaging of Airy Surface Plasmons

Alexander Minovich,[1] Angela E. Klein,[2] Norik Janunts,[2] Thomas Pertsch,[2] Dragomir N. Neshev,[1] and Yuri S. Kivshar[1]



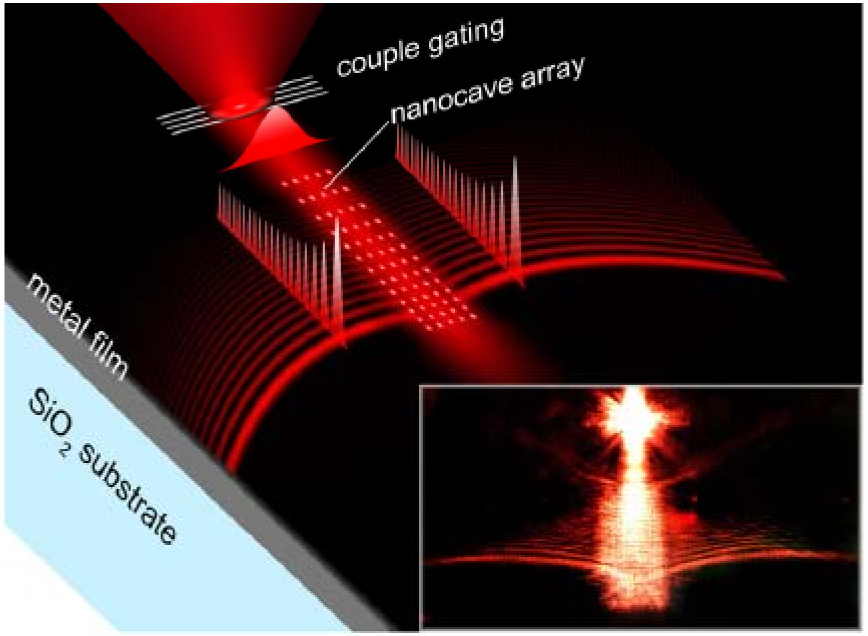


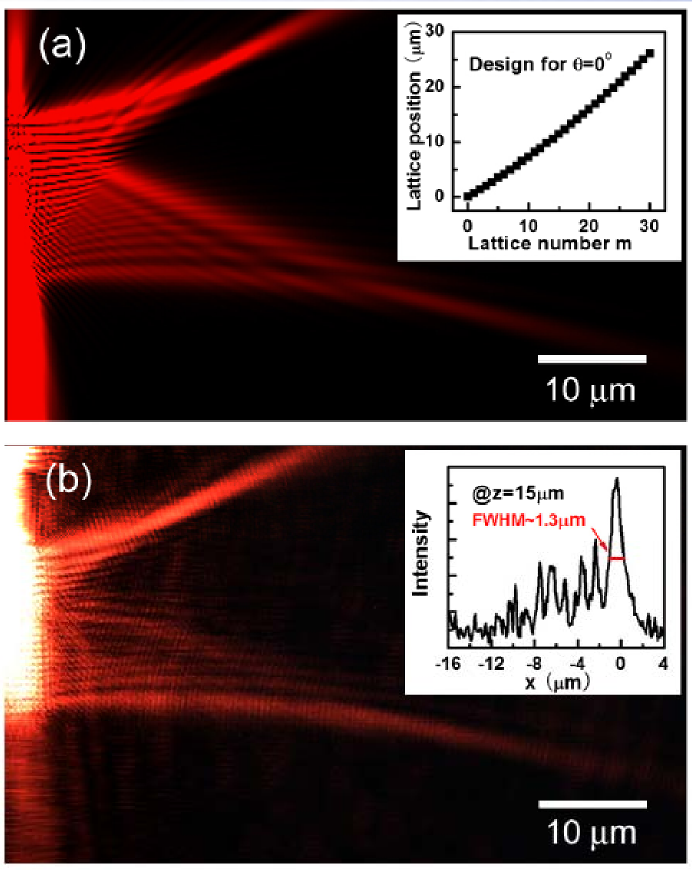
Using well designed nano-grating to couple Airy plasmon (coupling process)

PRL 107, 126804 (2011) PHYSICAL REVIEW LETTERS week ending 16 SEPTEMBER 2011

Plasmonic Airy Beam Generated by In-Plane Diffraction

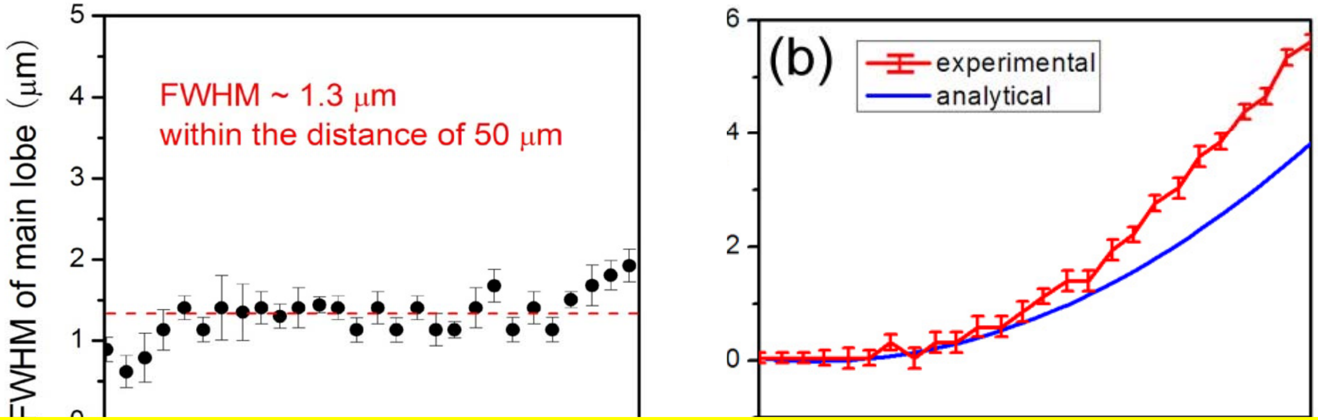
L. Li, T. Li,* S. M. Wang, C. Zhang, and S. N. Zhu



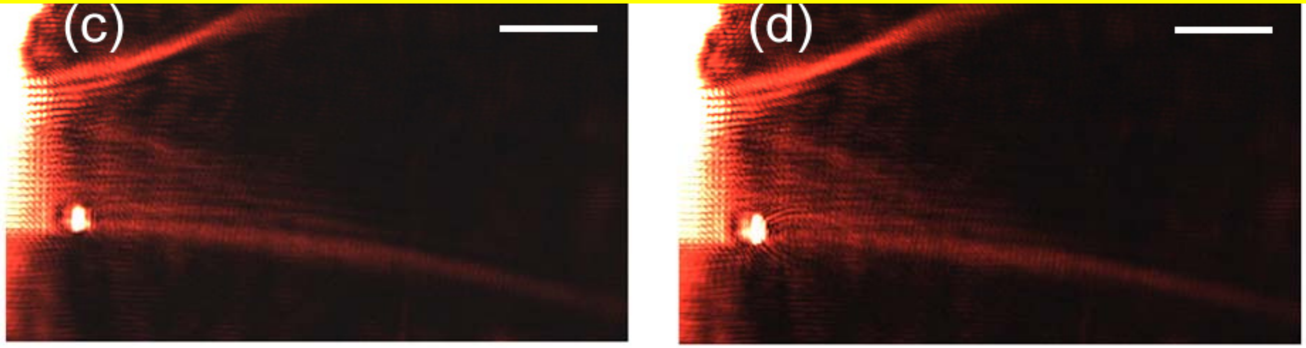


Generating Airy plasmon totally on planar dimension.
(independent to coupling process)

Non-spreading beam **Parabolic trajectory**



Q4：是否存在straight nondiffracting SPP?



Self-healing property

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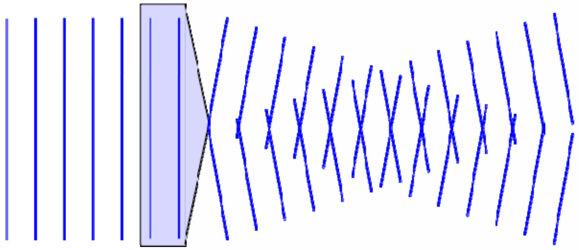
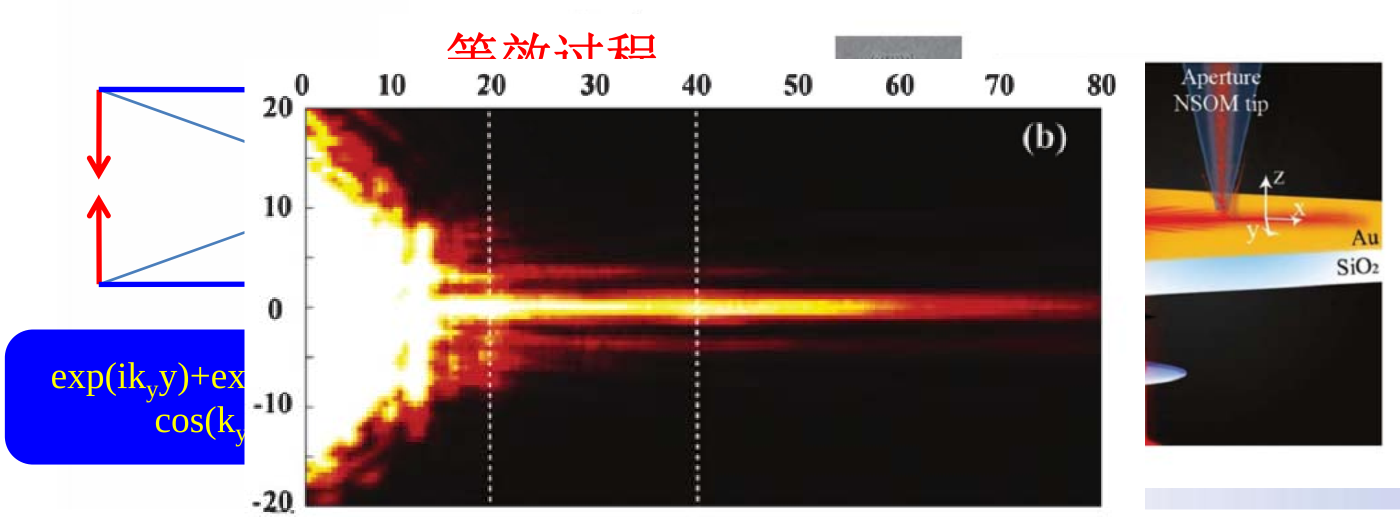
Cosine-Gauss plasmon



Bessel beam是柱坐标下平面波的叠加

而SPP仅仅存在金属表面2D体系，不可能适用柱坐标！

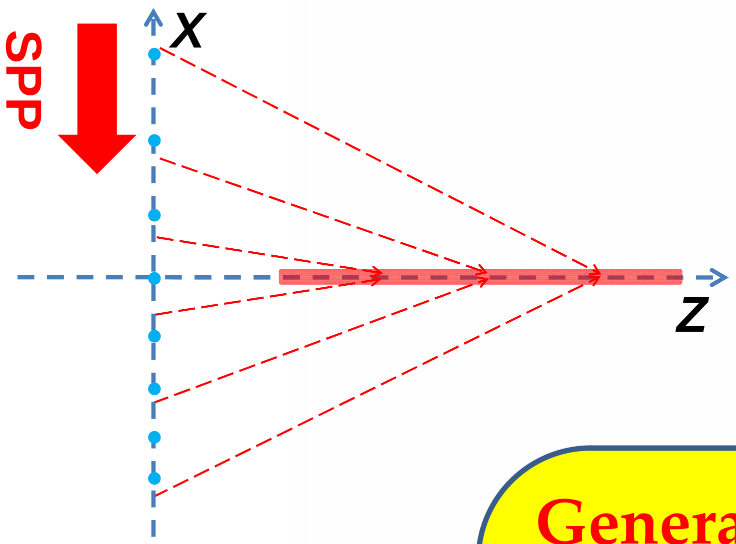


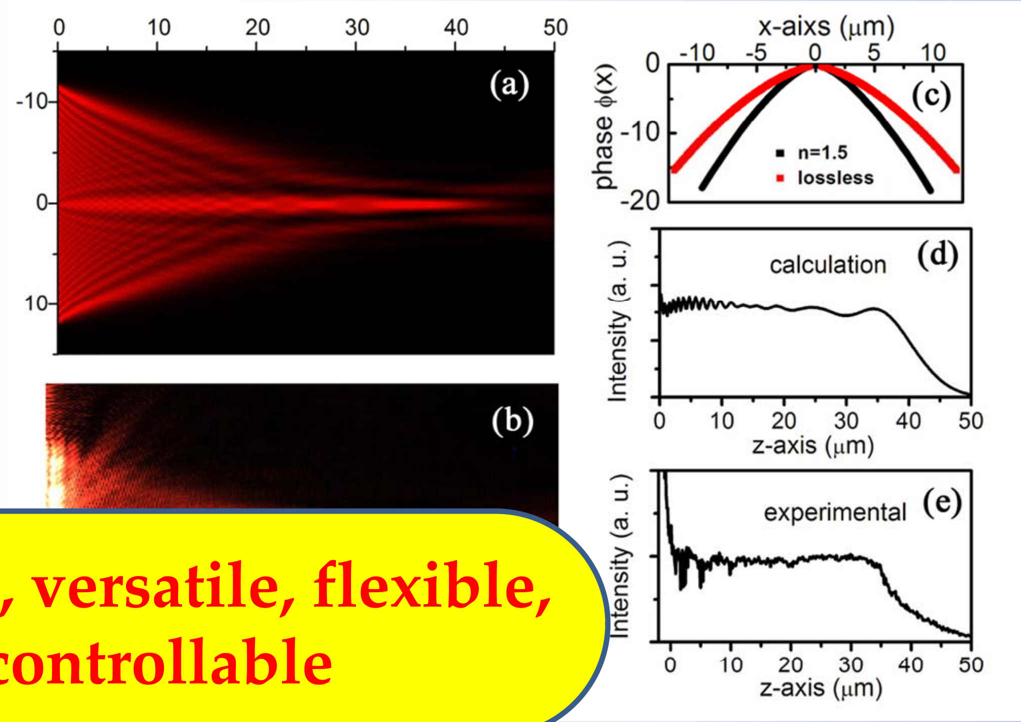
PRL **109,** 093904 (2012) PHYSICAL REVIEW LETTERS week ending 31 AUGUST 2012

Cosine-Gauss Plasmon Beam: A Localized Long-Range Nondiffracting Surface Wave

Jiao Lin,[1,2] Jean Dellinger,[3] Patrice Genevet,[1,4] Benoit Cluzel,[3] Frederique de Fornel,[3] and Federico Capasso[1,*]

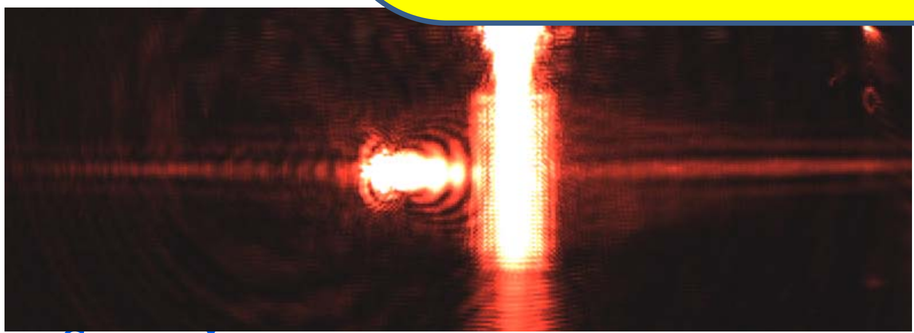
Our strategy- diffraction process





General, versatile, flexible, controllable

“lossless” SPP beam



Self-healing property

Any more?

Use your imagination,

but depends on your solid foundation!

Thanks!

需要ppt请登录 http://dsl.nju.edu.cn/litao/res/talk/

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- Opt. Lett. 38, 1733 (2013)
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