

# IOA Group

(Interferometry and Optics with Atoms)

*Laboratoire de Physique des Lasers*

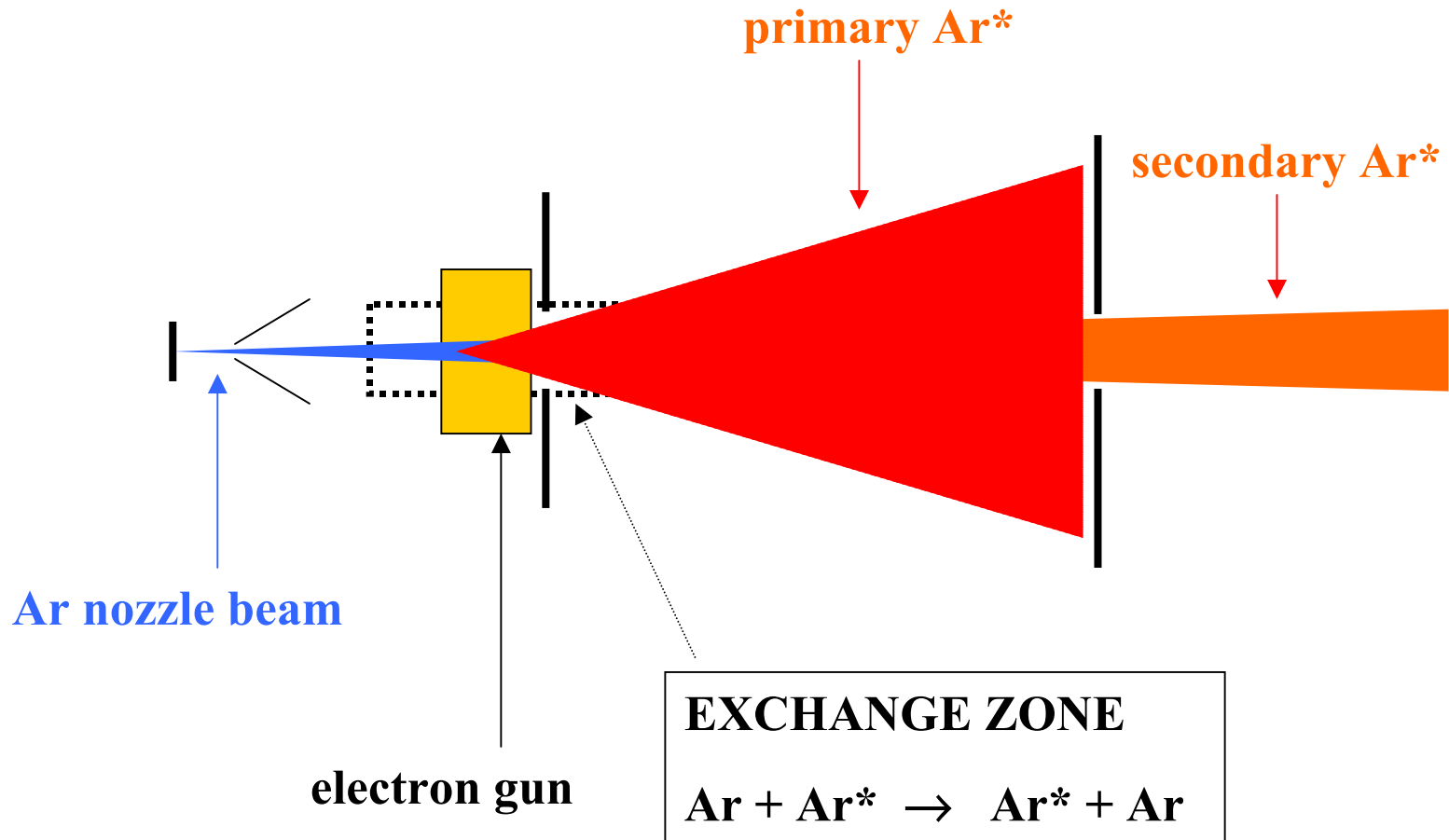
*Université Paris 13, Villetaneuse, France*

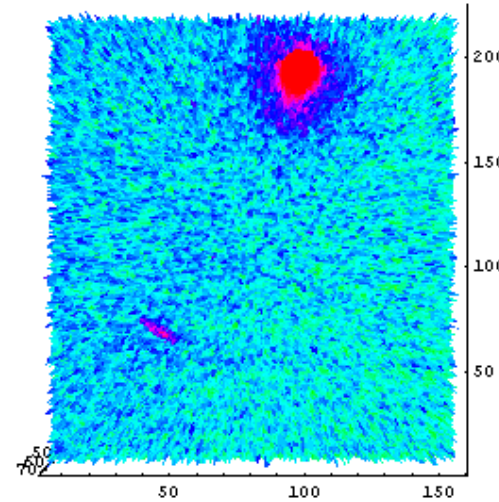
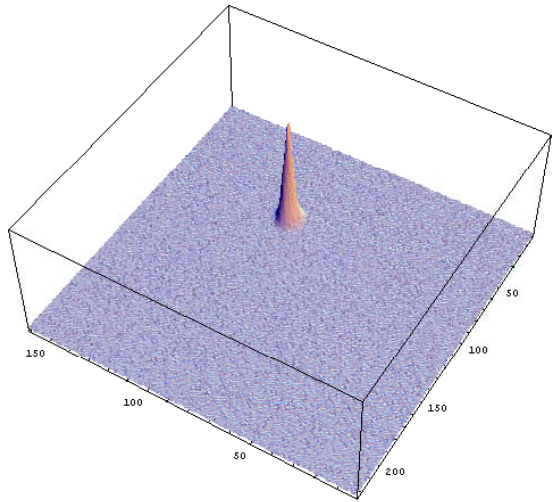
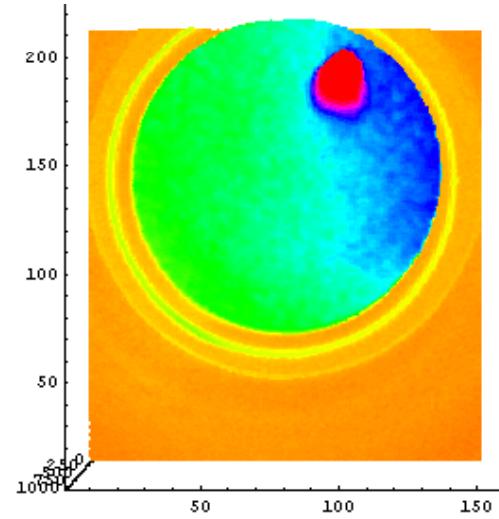
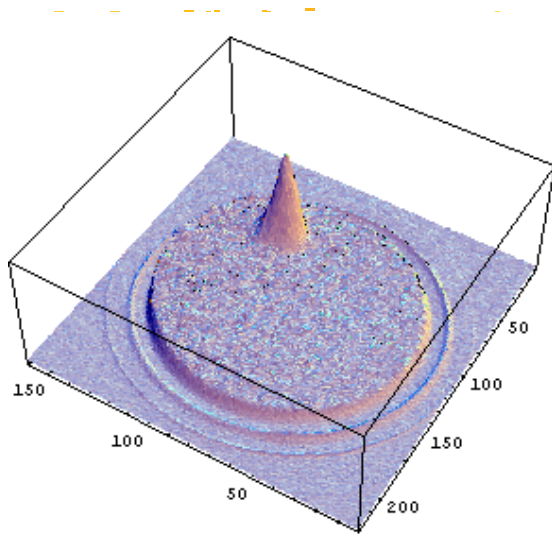
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# **INTERACTION OF METASTABLE ATOMS WITH MICRO AND NANO-STRUCTURED SURFACES**

- | NARROW METASTABLE BEAM**
- | PARTIAL COHERENCE EFFECT IN A NANO-SLIT GRATING**
- | VAN DER WAALS TRANSITIONS BETWEEN ZEEMAN SUB-LEVELS OF METASTABLE ARGON ATOMS (3P<sub>2</sub>)**

# A « NATURAL » METASTABLE ATOM BEAM





# MAIN CHARACTERISTICS OF THE BEAM

Angular aperture (FWHM) : **0.35 mrad**

Estimated velocity spread :  $< 1\%$

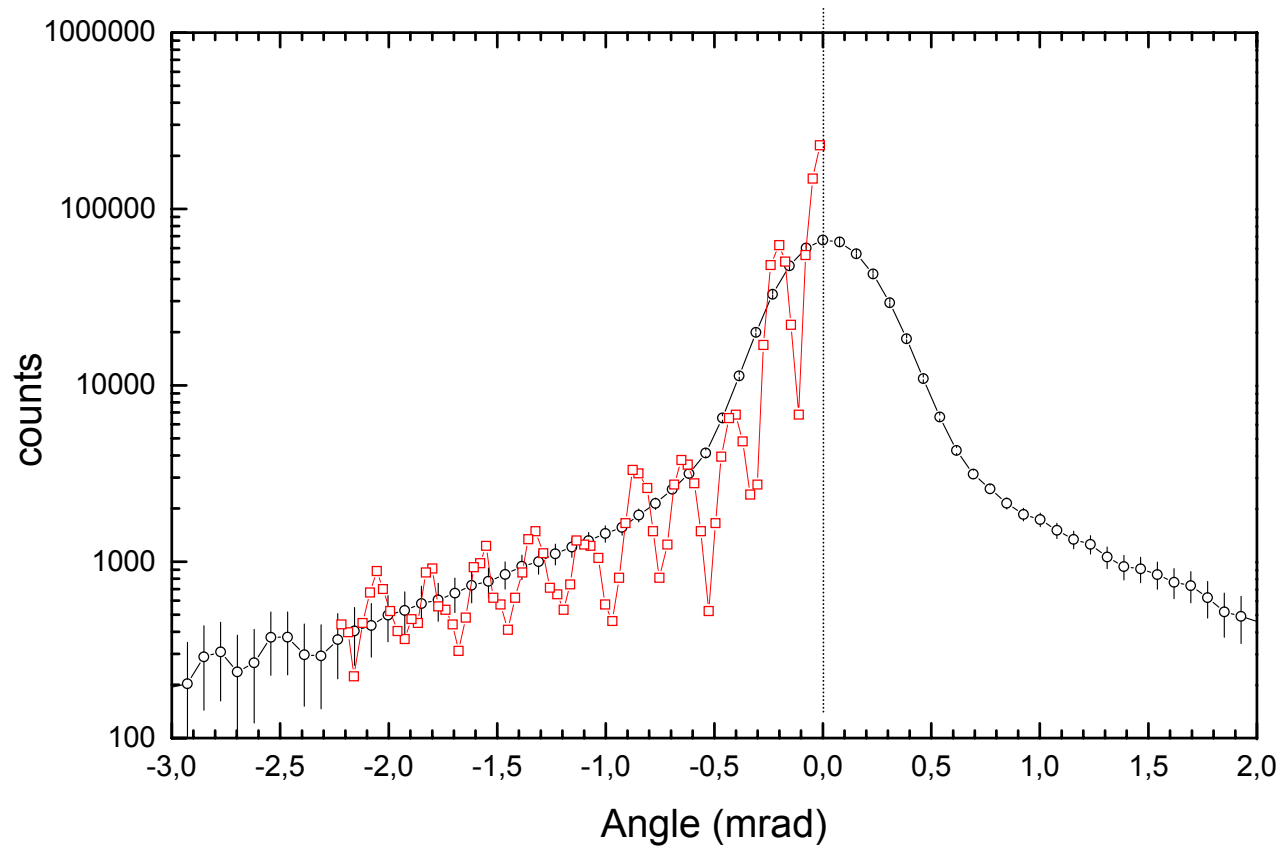
For Ar\* atoms :

- Longitudinal de Broglie wavelength : **0.018 nm**
- Mean tranverse de Broglie wavelength : **51.4 nm**
- Effective source diameter : **15  $\mu\text{m}$**
- Transverse coherence length : **400 nm**

**Analysis : diffraction by a Si<sub>3</sub>N<sub>4</sub> nano-slit grating**

# Ne\* atoms through a nano-slit grating

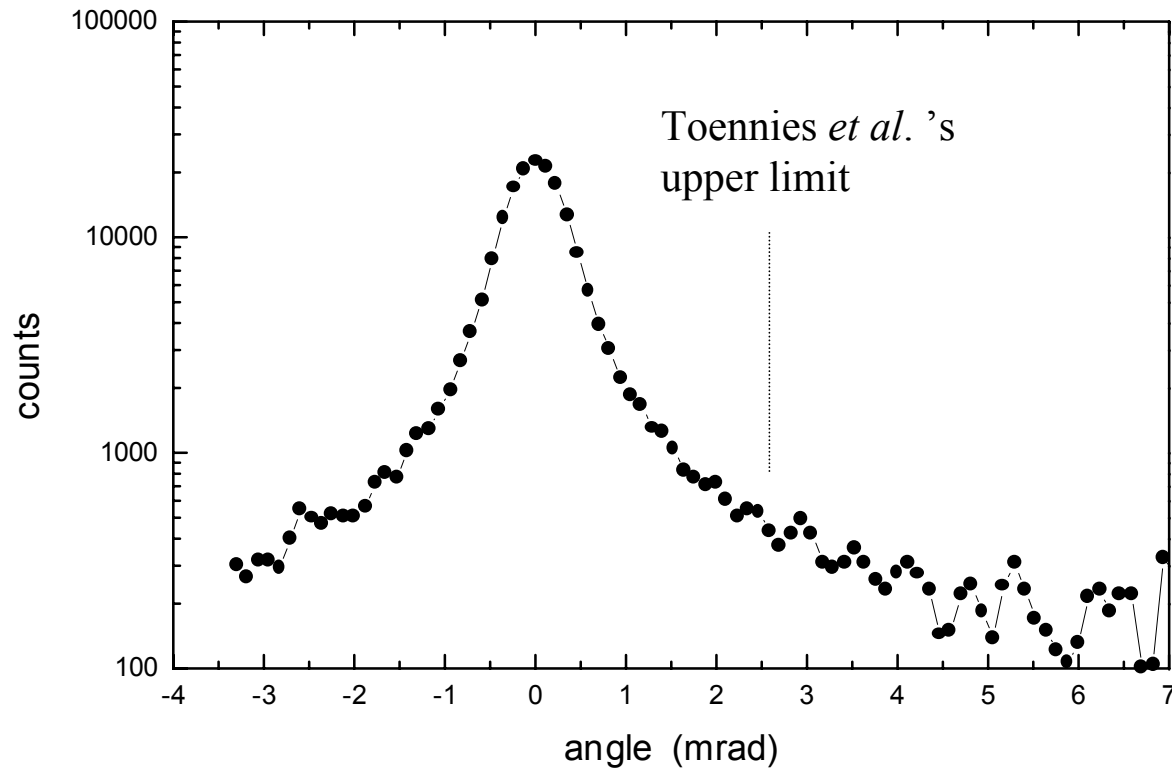
(slit width 50 nm, period 100 nm)



In red : Toennies *et al.* ; In black : present

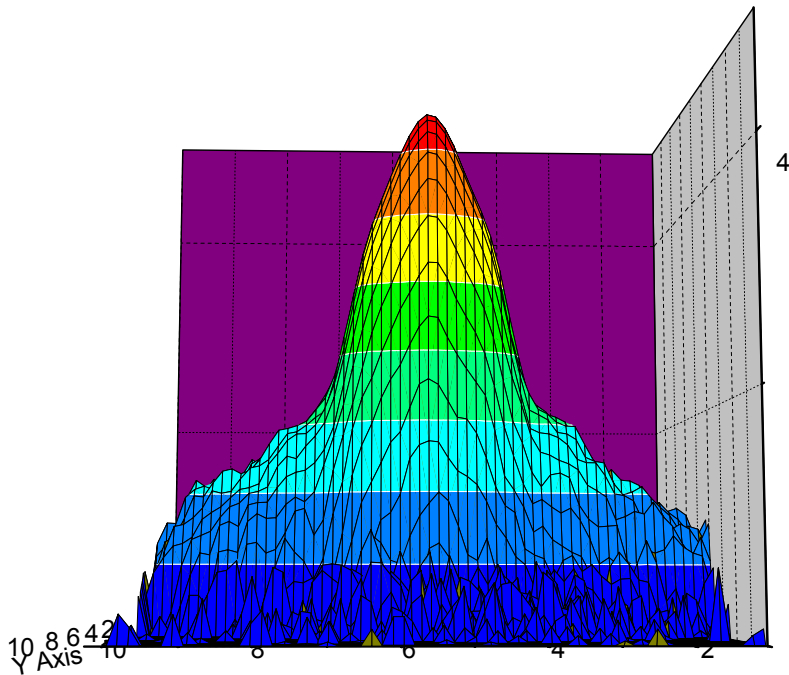
# Ne\* atoms, with an *inclined* grating (by 20°)

## High diffraction orders become visible

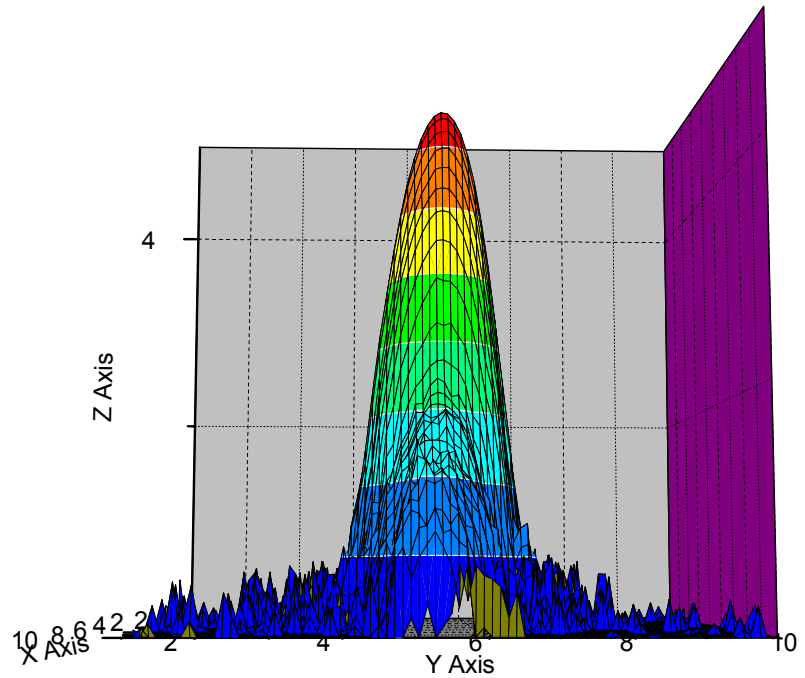


# 3D - TRANSVERSE PROFILE (He\*)

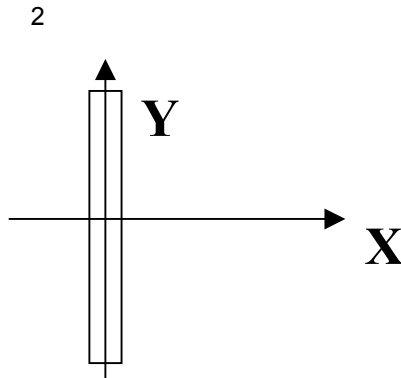
(log scale)



**X**

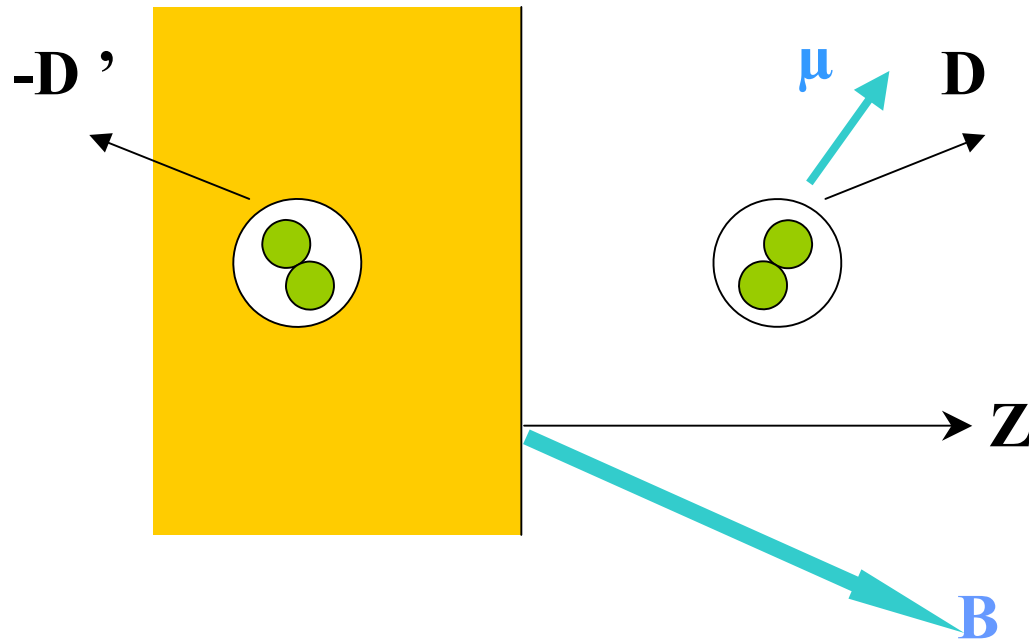


**Y**



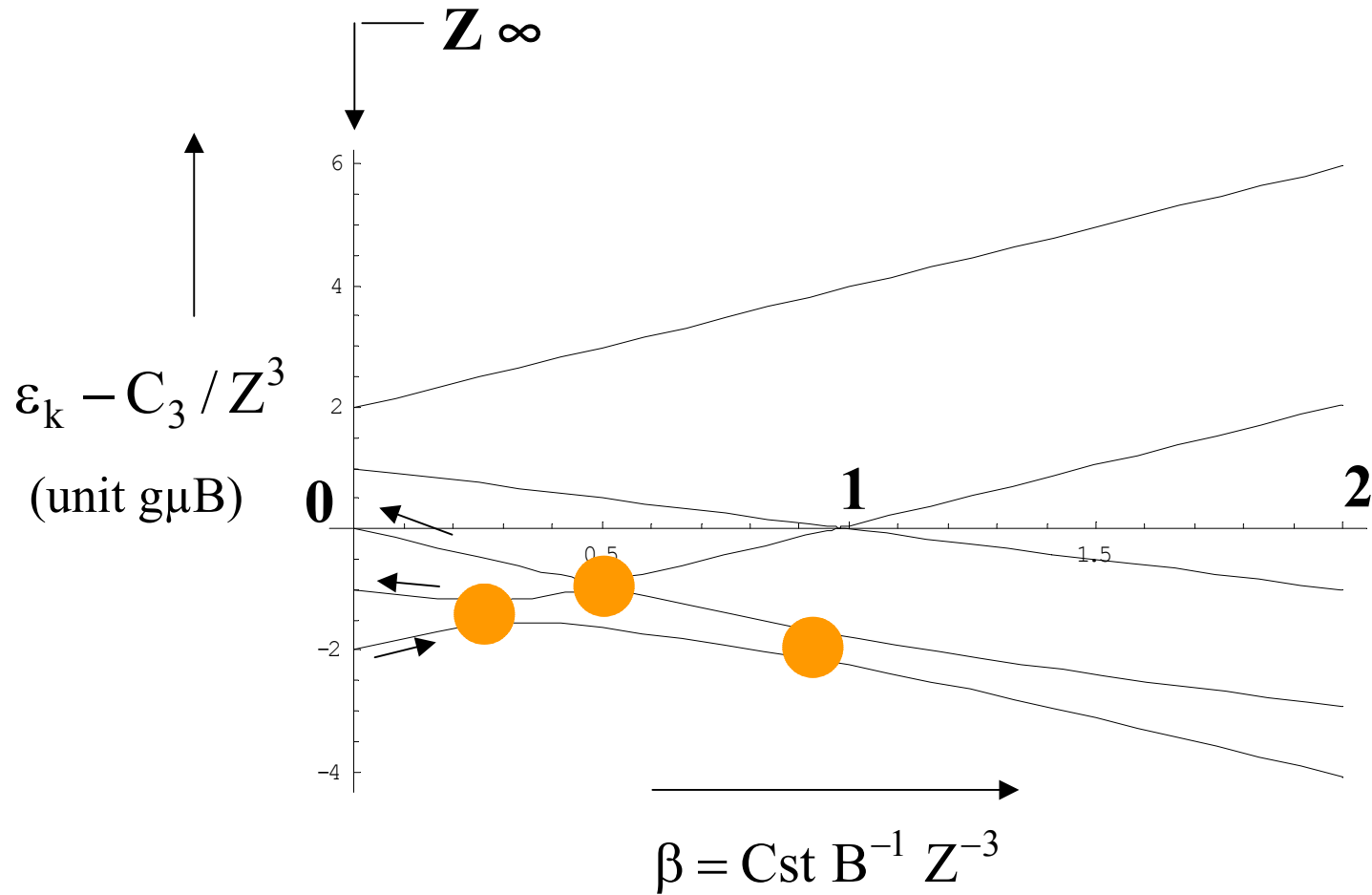


# VAN DER WAALS + ZEEMAN INTERACTION

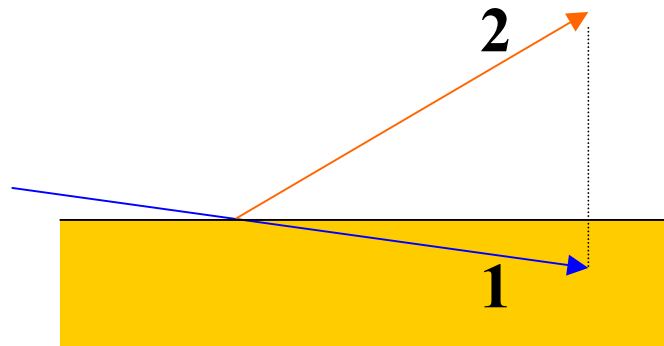


$$V = \frac{C_3}{Z^3} + g \mu_B B \left[ (J \cdot \hat{u}_B)^2 + \beta (J_Z^2 - \frac{1}{3} J^2) \right]$$

# EIGEN VALUES : AVOIDED CROSSINGS



# EXOERGIC vdW - ZEEMAN TRANSITION ( $\Delta M < 0$ )



$$\cos(\theta_2) = \frac{\cos(\theta_1)}{\sqrt{1 + \Delta E / E_0}}$$

$\Delta E$  = energy gain ;  $E_0$  = initial kinetic energy

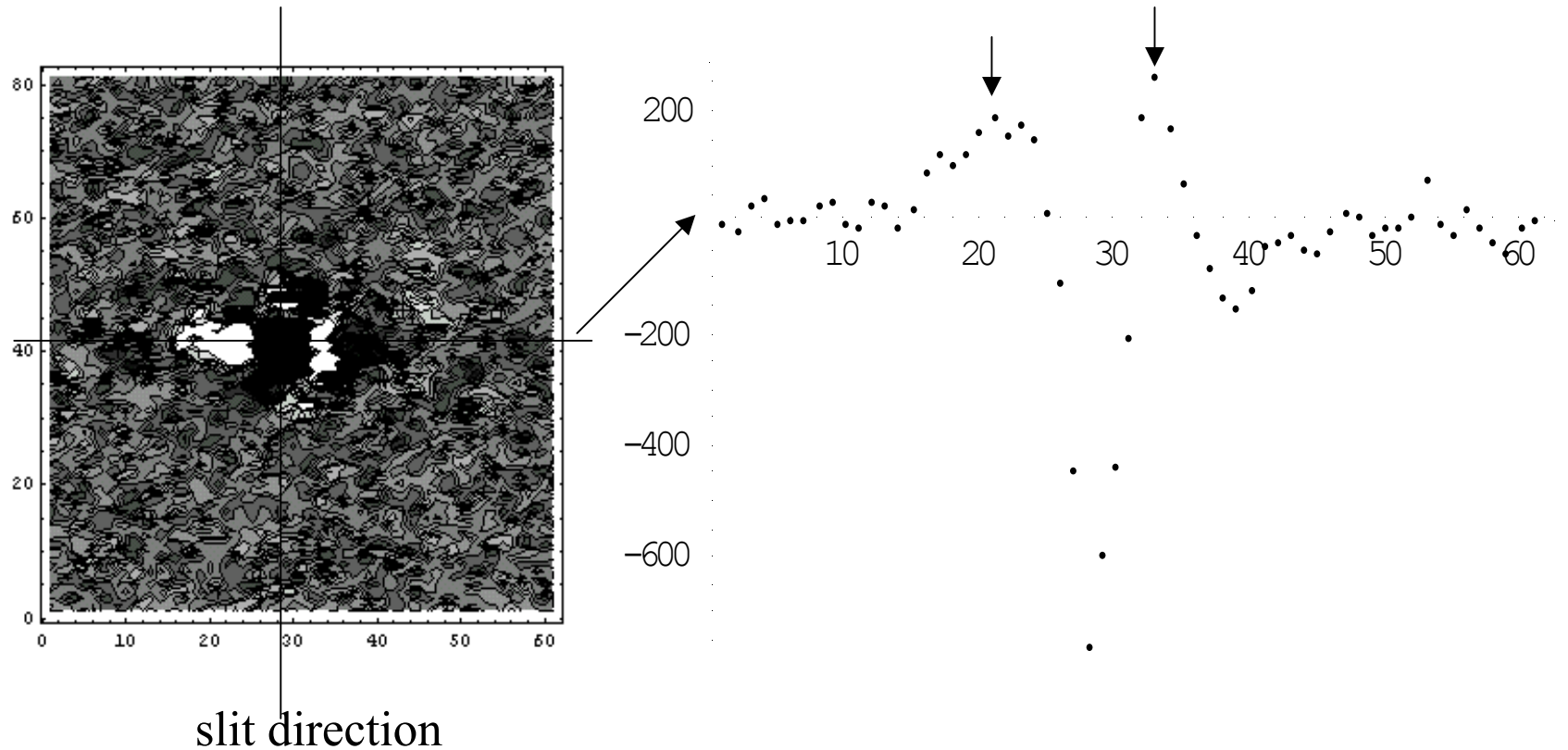
Typically, for  $B = 20\text{G}$ ,  $E_0 = 60\text{ meV}$ ,  $\theta_1 \approx 0$

$\rightarrow \theta_2 \approx 1.4\text{ mrad}$

# vdW - Zeeman transition in Ne\*

$B_{\text{perp.}} = 22\text{G}$  ;  $B_{\text{paral.}} = 0.4\text{G}$

$I(B) - I(0)$  , with  $I(0)_{\text{max}} \approx 40000$  ( $P \approx 2\%$ )



## Planned Experiment : vdw-Zeeman with slow atoms

$$\text{tg } \theta_2 = (\Delta E / E_0)^{1/2} \quad \text{with } E_0 \sim \Delta E$$

$$\Delta E / E_0 = 6 \cdot 10^{-4} \text{ B(G)}$$

A first step towards a new atom interferometer

