

# Role of the Coulomb-nuclear interference in the low-energy elastic scattering of halo nuclei

**ALEXIS DIAZ-TORRES**



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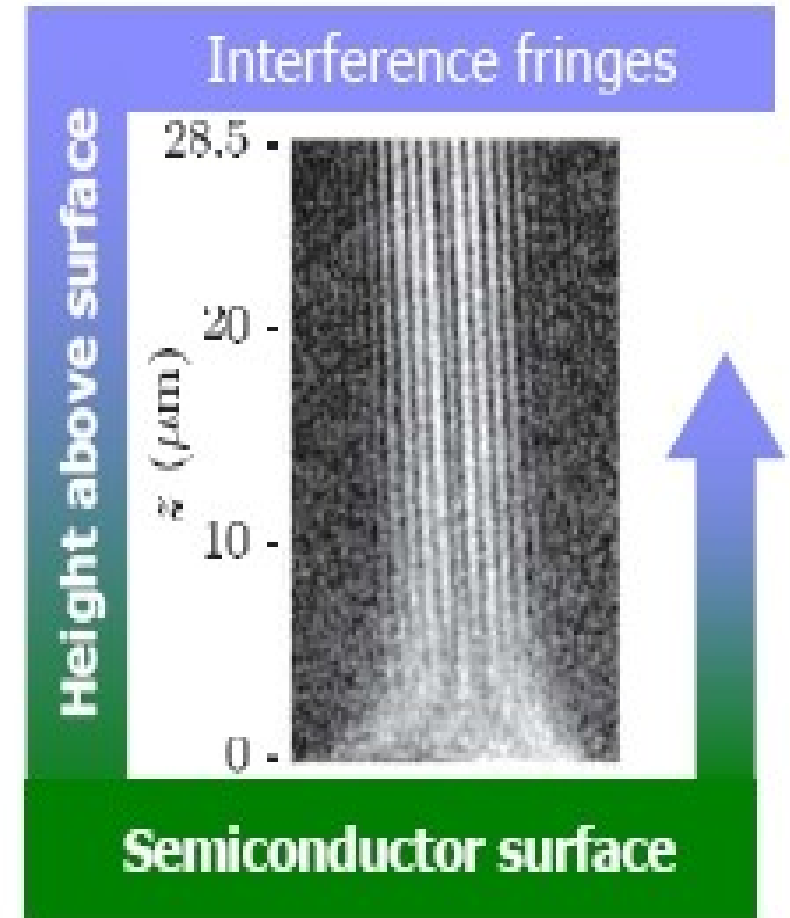
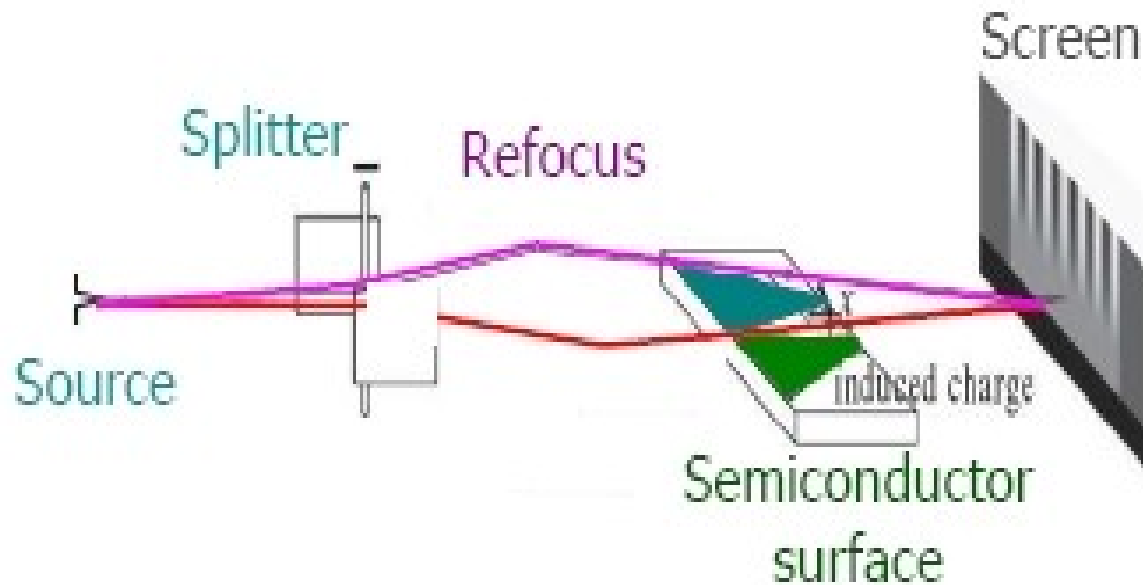
**What I will tell you**

- ★ Motivation
- ★ Near-barrier elastic scattering of  $^{11}\text{Be} + ^{64}\text{Zn}$
- ★ Conclusions & Outlook

# Loss of Quantum Coherence

## Electron entanglement with a surface

Double-slit type experiment with single electrons

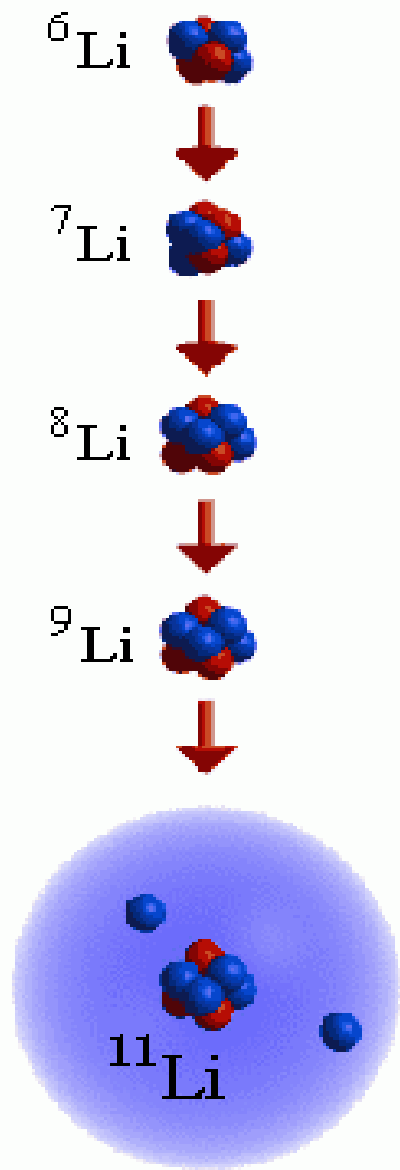


Sonntag & Hasselbach, PRL **98** (2007) 200402

Courtesy of David Hinde

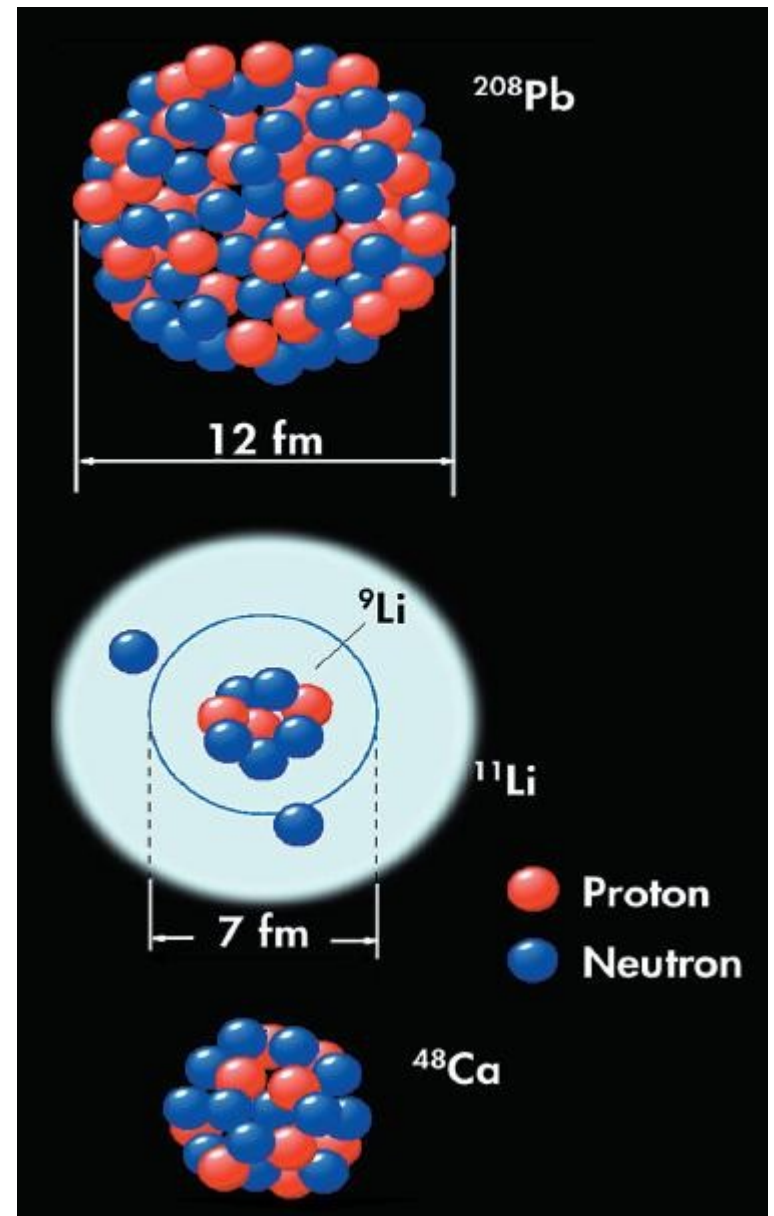
- Decoherence – “dynamical delocalization of quantum mechanical superpositions” (H.D. Zeh arXiv:quant-ph/0512078 v2) coherence shared with (lost in) environment

# Open Quantum Systems: Halo Nuclei



$$S_n = 4.06 \text{ MeV}$$

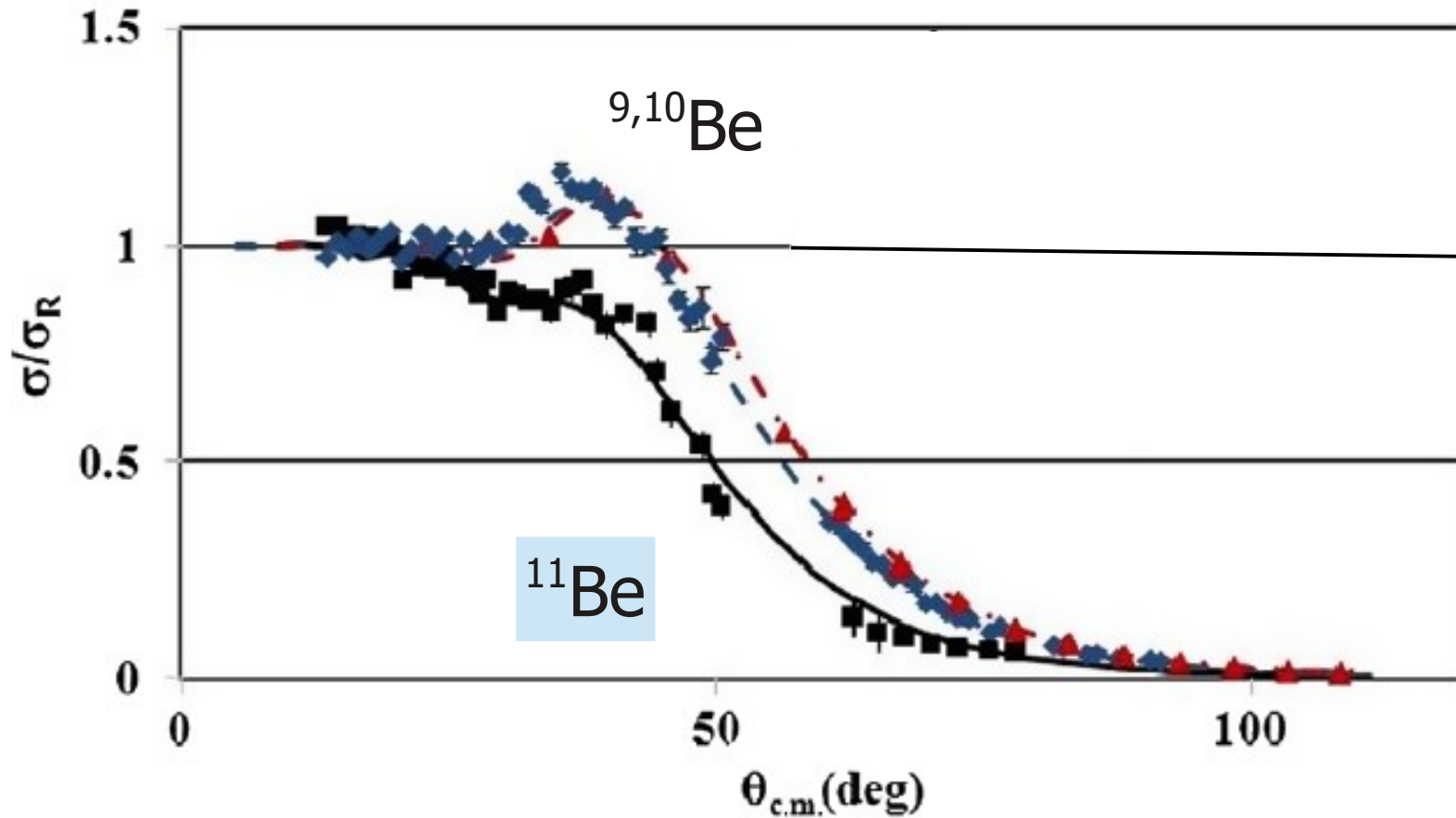
$$S_n = 0.32 \text{ MeV}$$





# Elastic scattering of Beryllium isotopes by the $^{64}\text{Zn}$ target

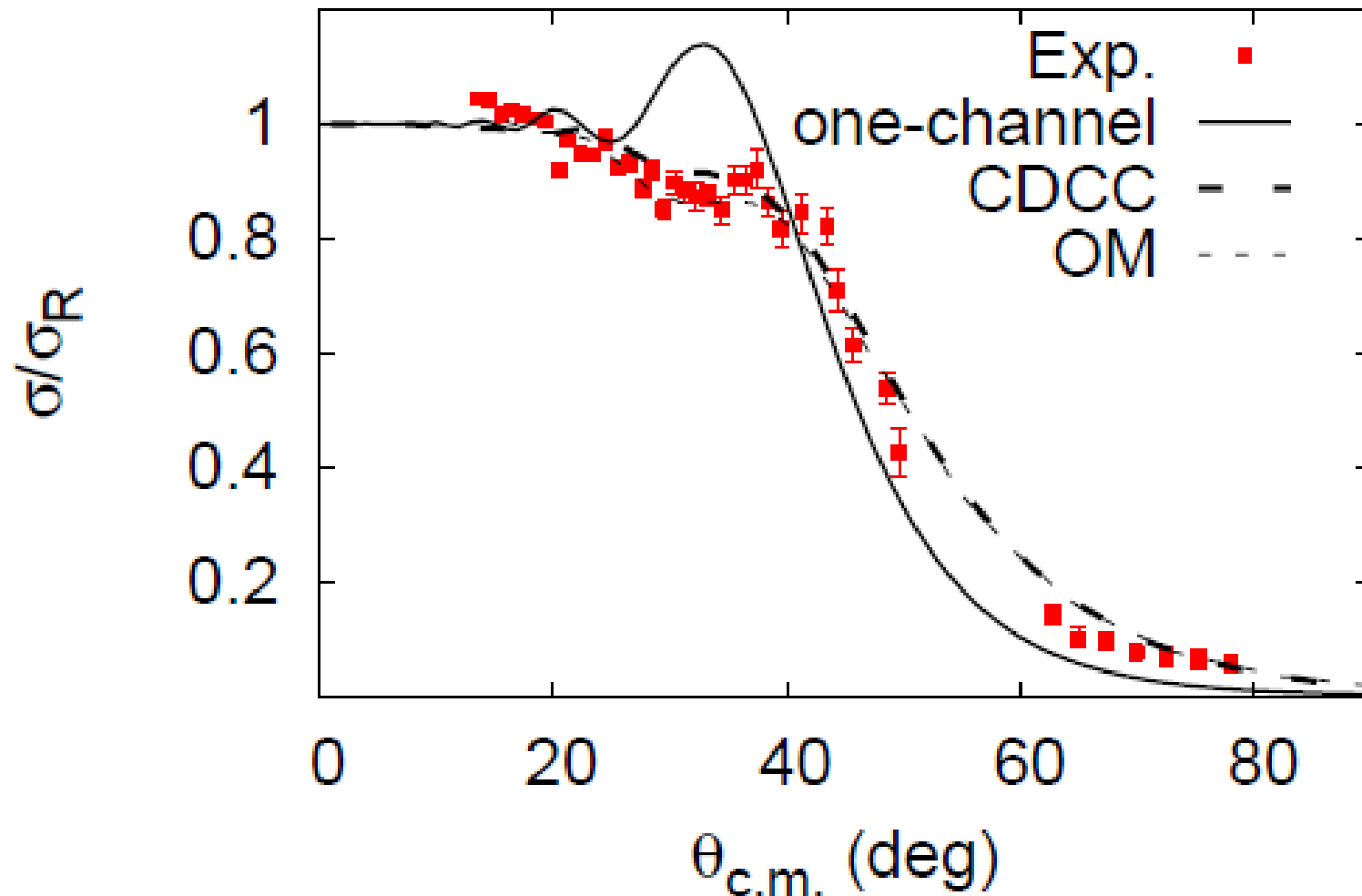
A. Di Pietro et al, PRL **105** (2010) 022701



Suppression of the Coulomb-nuclear interference peak for  $^{11}\text{Be}$

# Elastic scattering of $^{11}\text{Be} + ^{64}\text{Zn}$ at $E_{\text{cm}} = 24.5$ MeV

A. Di Pietro et al, PRC **85** (2012) 054607



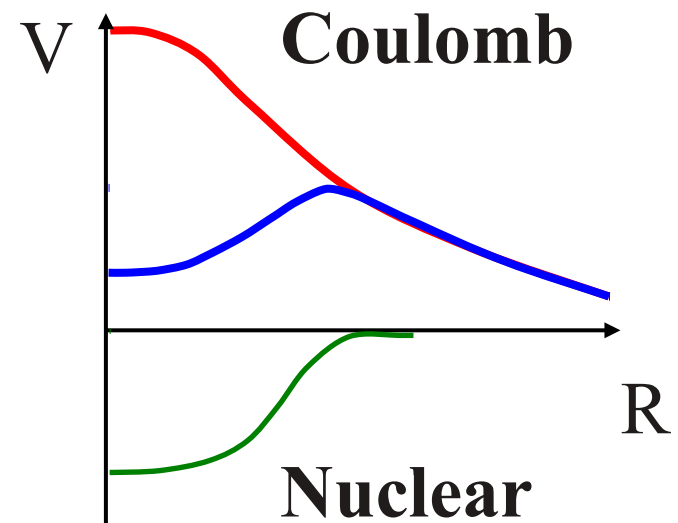
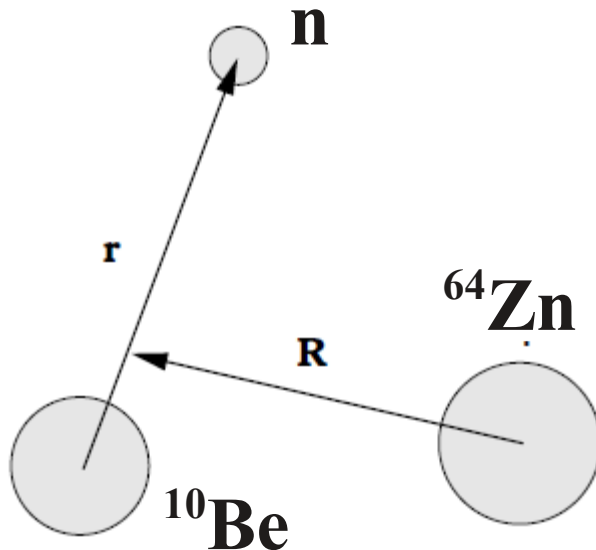
# Some Formulae

G.R. Satchler, Direct Nuclear Reactions (Clarendon Press, Oxford, 1983)

$$\sigma/\sigma_R = 1 + \frac{|f_N(\theta)|^2}{|f_C(\theta)|^2} + \frac{2 \operatorname{Re} [f_C^*(\theta) f_N(\theta)]}{|f_C(\theta)|^2}$$

**Nuclear**

**Coulomb-nuclear  
interference**



# Some Formulae

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**Nuclear**

**Coulomb-nuclear  
interference**

$$f_C(\theta) = -\frac{\eta}{2k \sin^2(\theta/2)} e^{-i\eta \ln \sin^2(\theta/2) + 2i\sigma_0}$$

$$g(\theta) = f_C(\theta) + \frac{i}{2k} \sum_L [(2L+1) - (L+1)S_L^+ - LS_L^-] e^{2i\sigma_L} P_L(\cos \theta)$$

$$h(\theta) = \frac{i}{2k} \sum_L (S_L^- - S_L^+) e^{2i\sigma_L} P_L^1(\cos \theta)$$

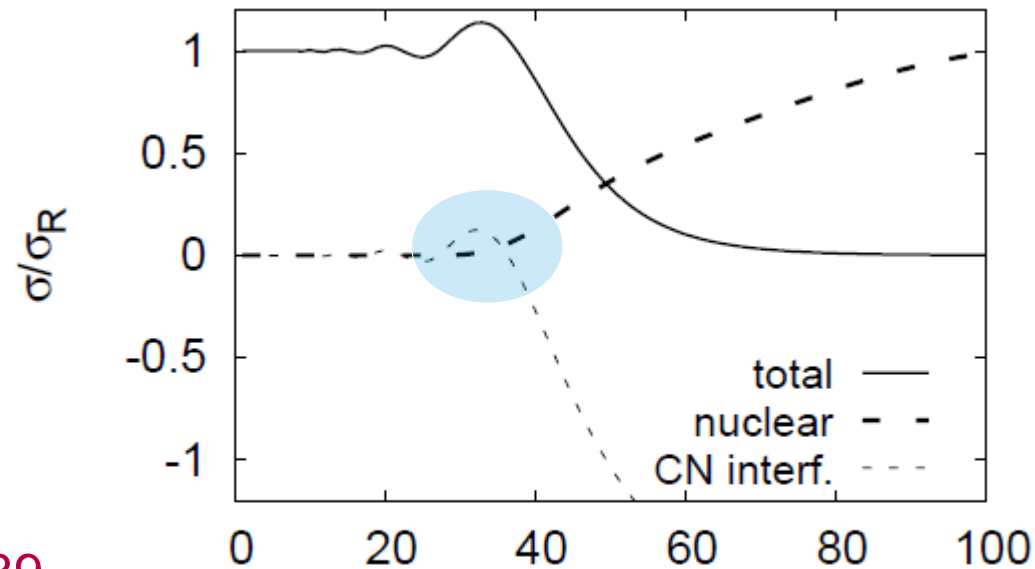
$$\frac{d\sigma(\theta)}{d\Omega} = |g(\theta)|^2 + |h(\theta)|^2$$

**Particles with spin 1/2**



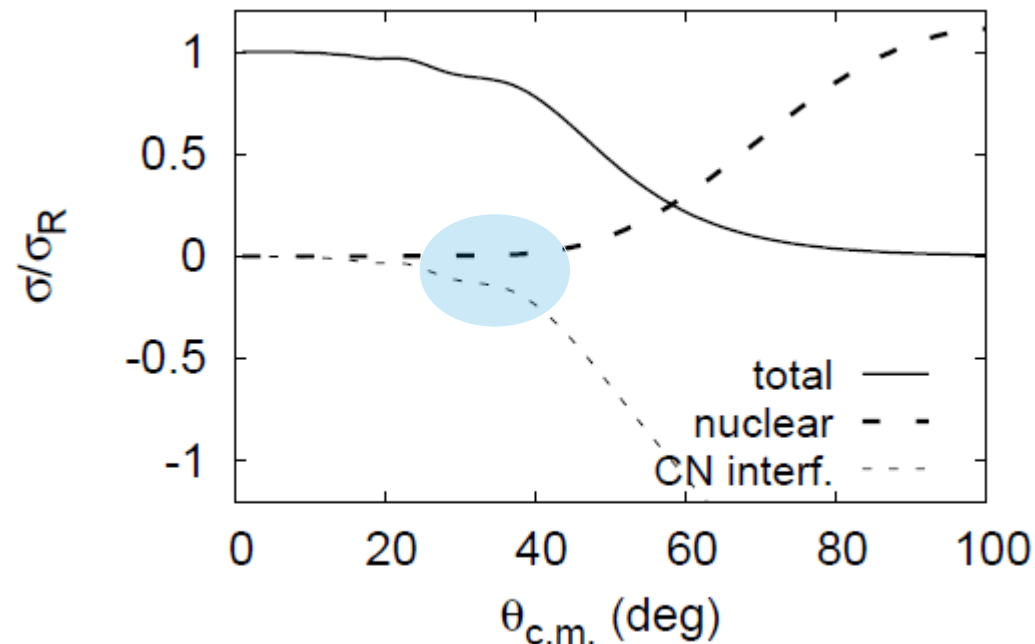
# Decomposition of the elastic-scattering angular distribution

$^{11}\text{Be} + ^{64}\text{Zn}$  @  $E_{\text{cm}} = 24.5$  MeV



**one-channel**

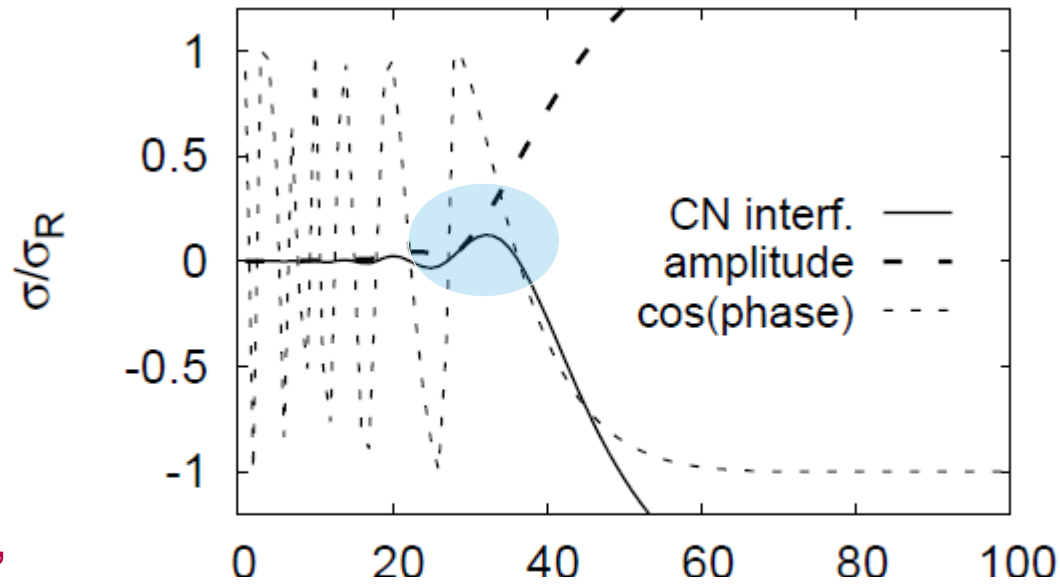
ADT & Moro,  
PLB 733 (2014) 89



**CDCC**

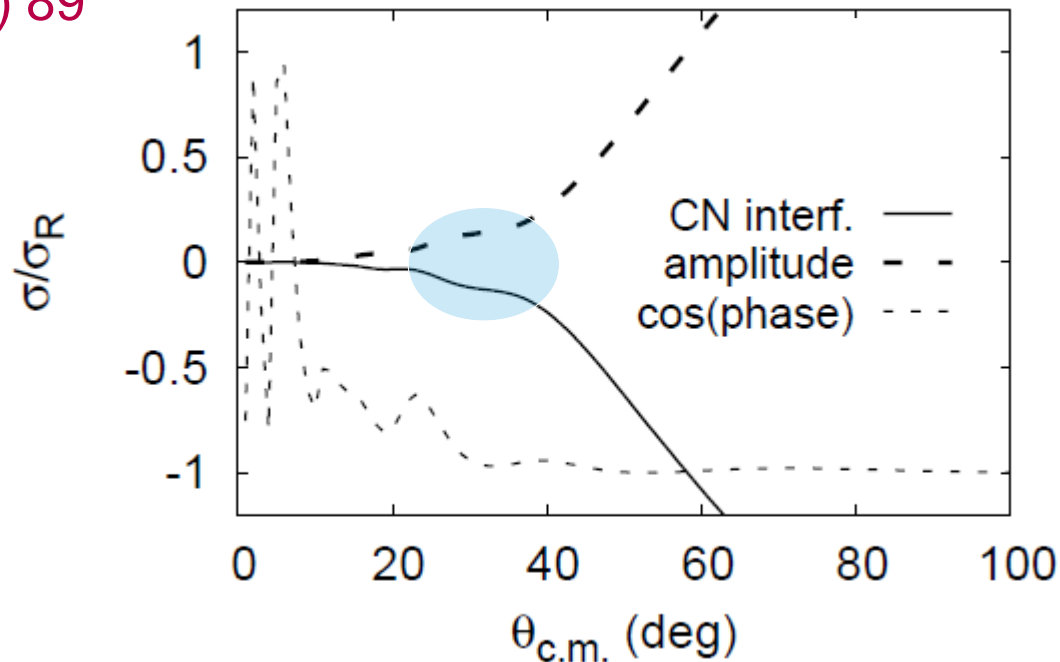
# Decomposition of the Coulomb-nuclear interference term

$^{11}\text{Be} + ^{64}\text{Zn}$  @  $E_{\text{cm}} = 24.5$  MeV



**one-channel**

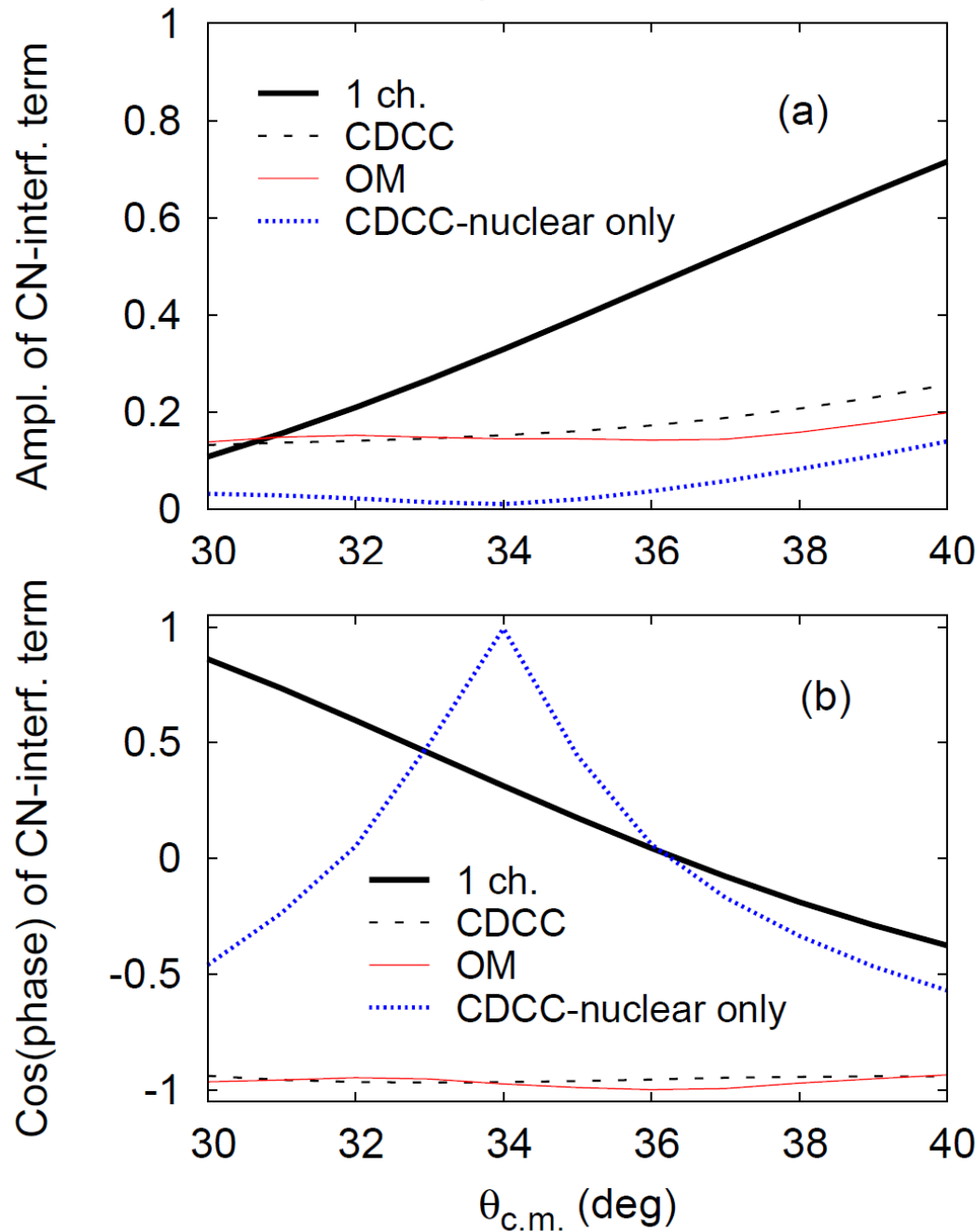
ADT & Moro,  
PLB 733 (2014) 89



**CDCC**

# Amplitude & Phase of the Coulomb-nuclear interference

$^{11}\text{Be} + ^{64}\text{Zn}$  @  $E_{\text{cm}} = 24.5$  MeV



**Amplitude**

**Cosine  
of the  
Phase**

ADT & Moro,

PLB 733 (2014) 89



## What I told you

- ★ The Coulomb-nuclear interference is critical for the elastic-scattering angular distribution.
- ★ The Coulomb-nuclear interference declines and becomes destructive due to continuum couplings.
- ★ Could the elastic-scattering of halo nuclei be a tool for investigating the dynamics of open quantum systems in nuclear physics?

Halo Projectile	→	Breakup Threshold
Target Nucleus	→	Breakup Couplings
Incident Energy	→	Control Variable