

Two-Photon Double Ionisation

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P. Balcou et coll. (LOA - ENSTA)

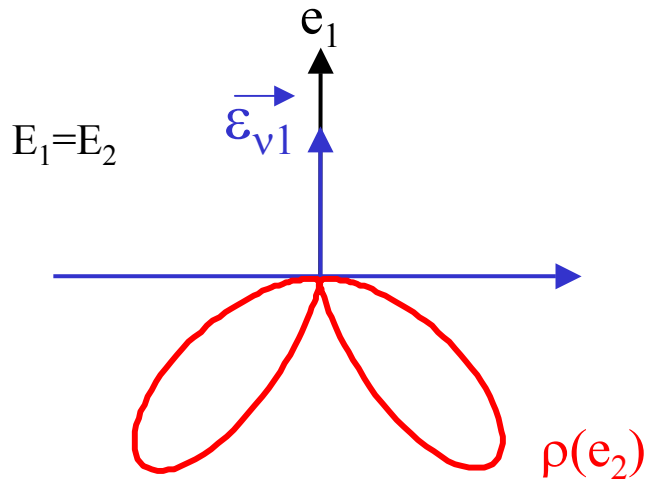
R. Moshhammer et coll. (MPI - Heidelberg)



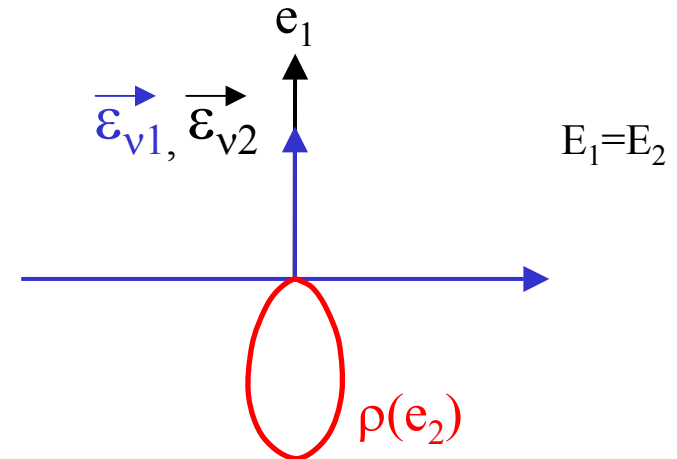
Two-Photon Double Ionisation

Symmetry of the final state

1-photon



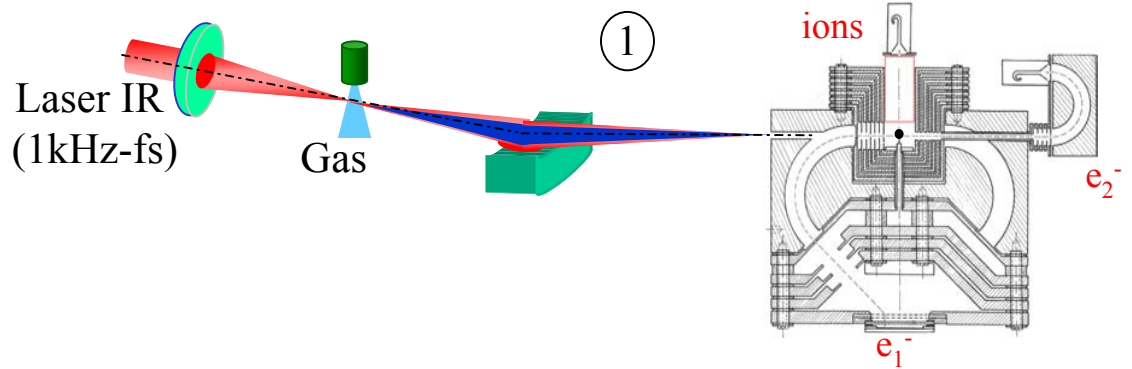
2-photon



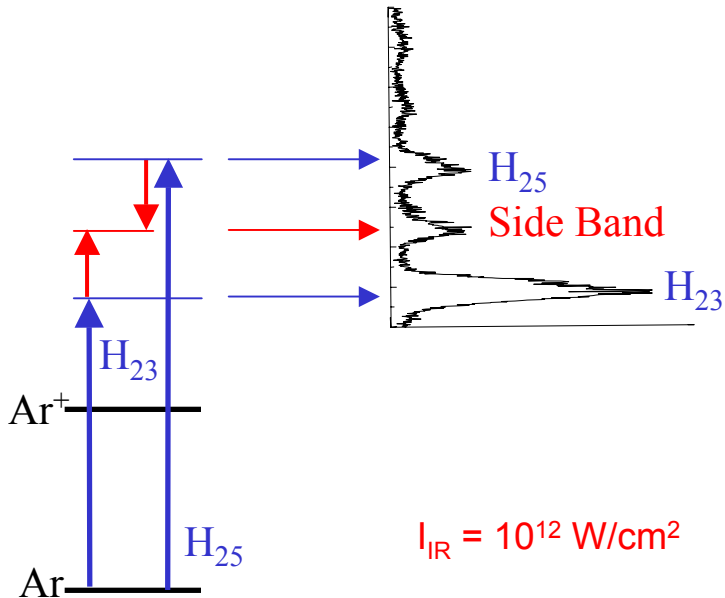
Two-Photon Double Ionisation

	2 colors	1 color
Sources	HHG + IR (available)	FEL (near futur)
Atomic Species	Xe	He Ne, Ar, Kr, Xe
Field regime (W/cm ²)	Middle to Strong field 10 ¹¹ -10 ¹⁶	Strong field 10 ¹² -10 ¹⁵
Ponderomotive Energy (U _p)	meV - eV	< meV

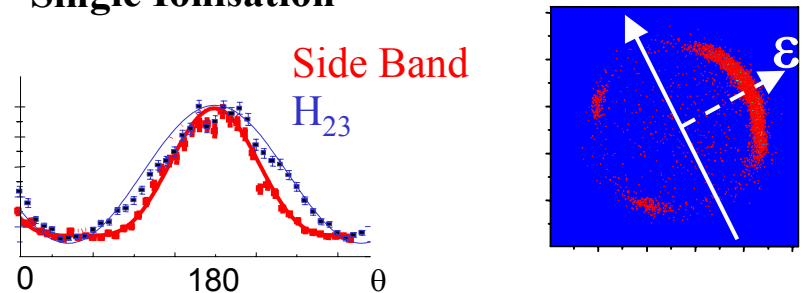
Towards 2-Photon Double Ionisation of Xe HHG + IR



② Photoelectron spectrum - Single Ionisation -

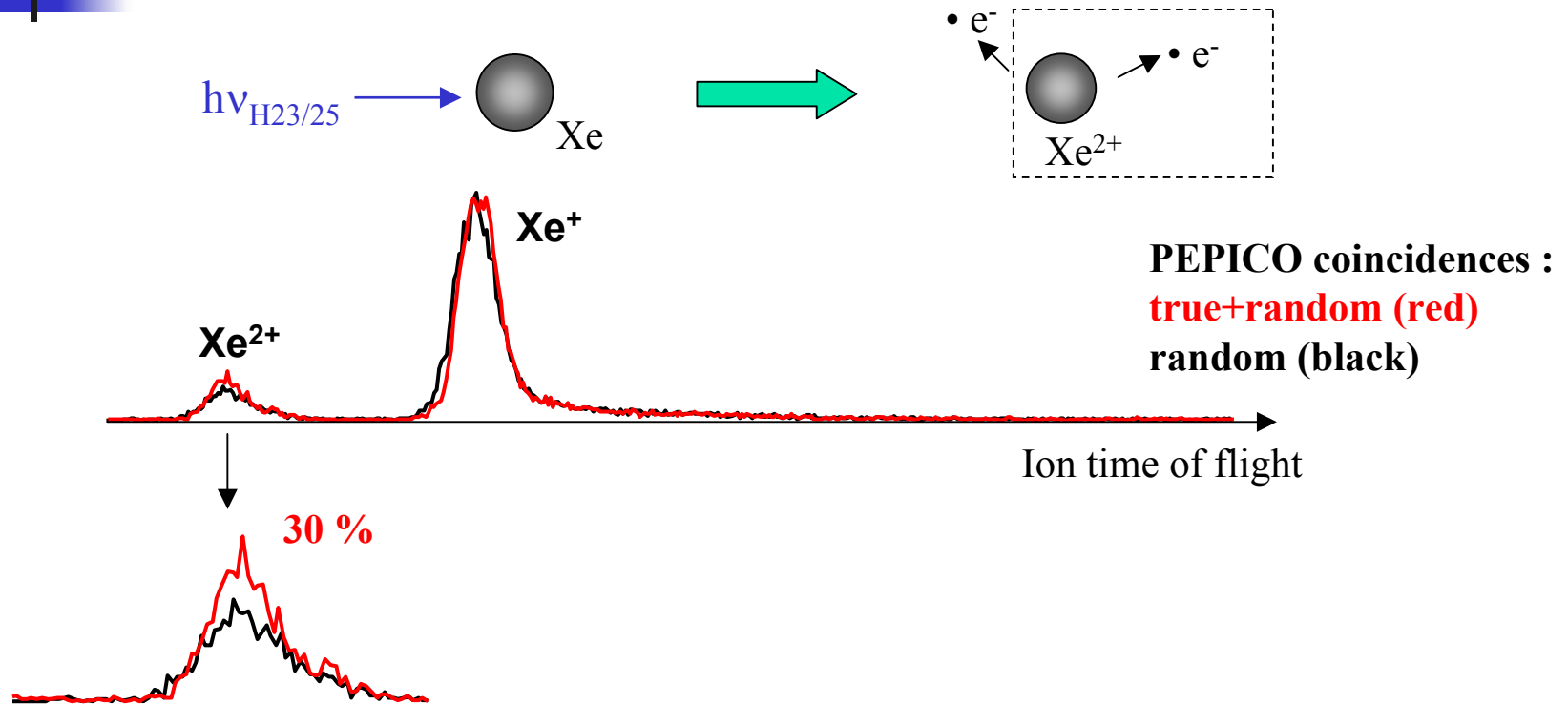


③ Angular distribution e_1^- - Single Ionisation -



$$\frac{d\sigma_{\text{m-ph}}}{d\Omega} = \frac{\sigma}{4\pi} \left(1 + \sum_{i=1}^m \beta_{2i} P_{2i}(\cos\theta) \right)$$

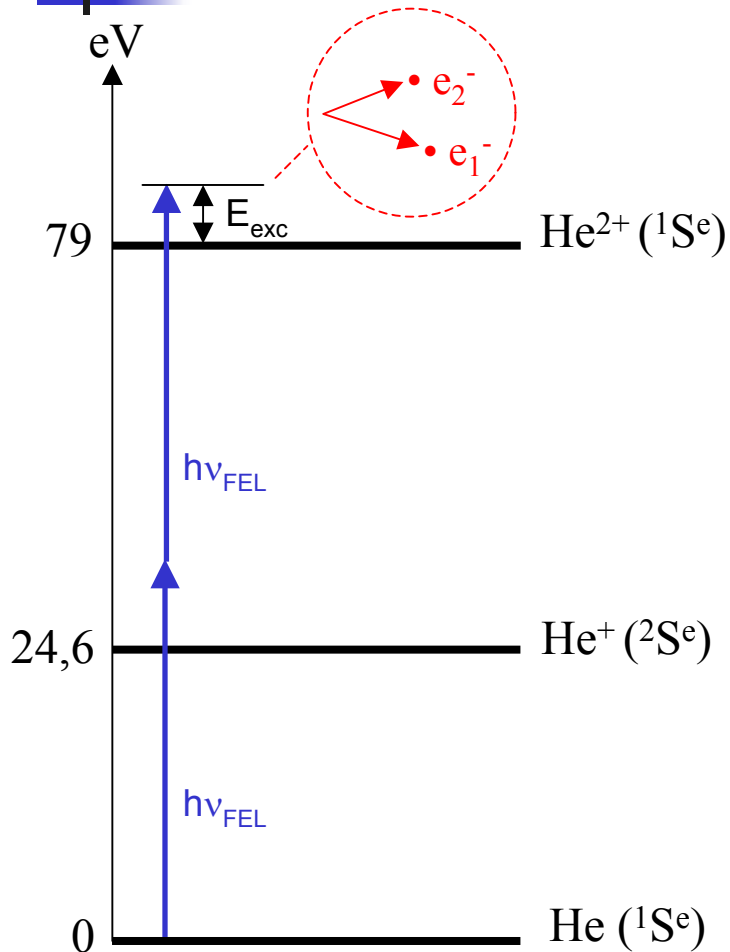
Towards 2-Photon Double Ionisation of Xe HHG + IR



Two developments in progress:

- HHG source filtered
- 4π Collection & Detection for all particles (momentum imaging)

2-Photon Double Ionisation FEL+FEL Complete Experiment



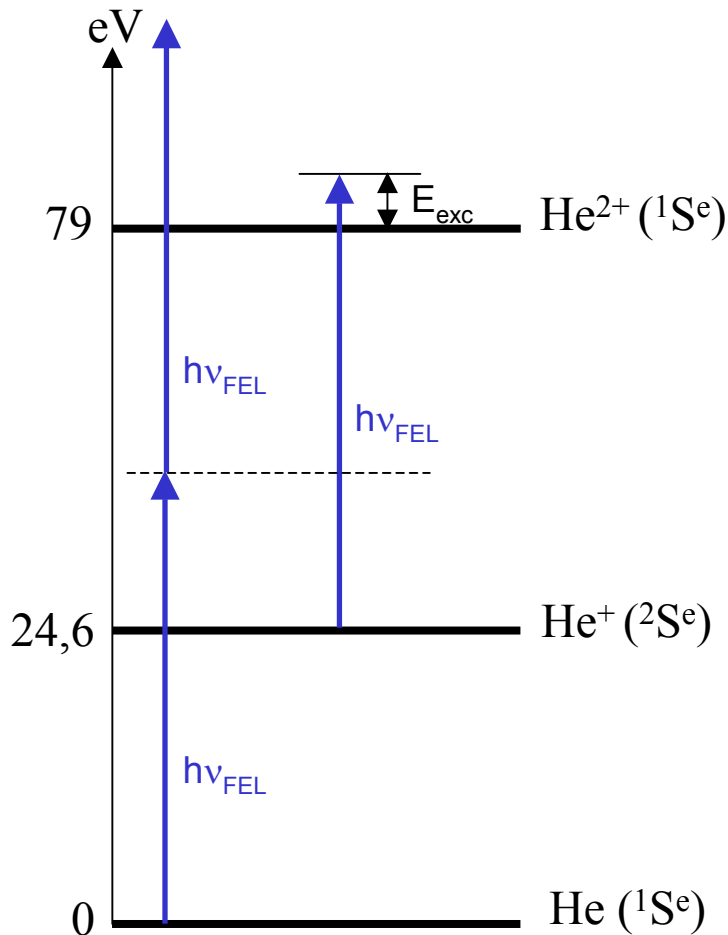
• Two Photon Direct Double Ionisation

E_{exc} (eV)	$h\nu_{\text{FEL}}$ (eV)	Laser Harmonic	Undulator Harmonic
4,7	41,84	9	3
23,3	51,14	11	3
29,5	54,24	7	5

Selecting different harmonics (laser, undulator)

→ access to different kinematics of the
2-Photon Double Ionisation

2-Photon Double Ionisation FEL+FEL Complete Experiment

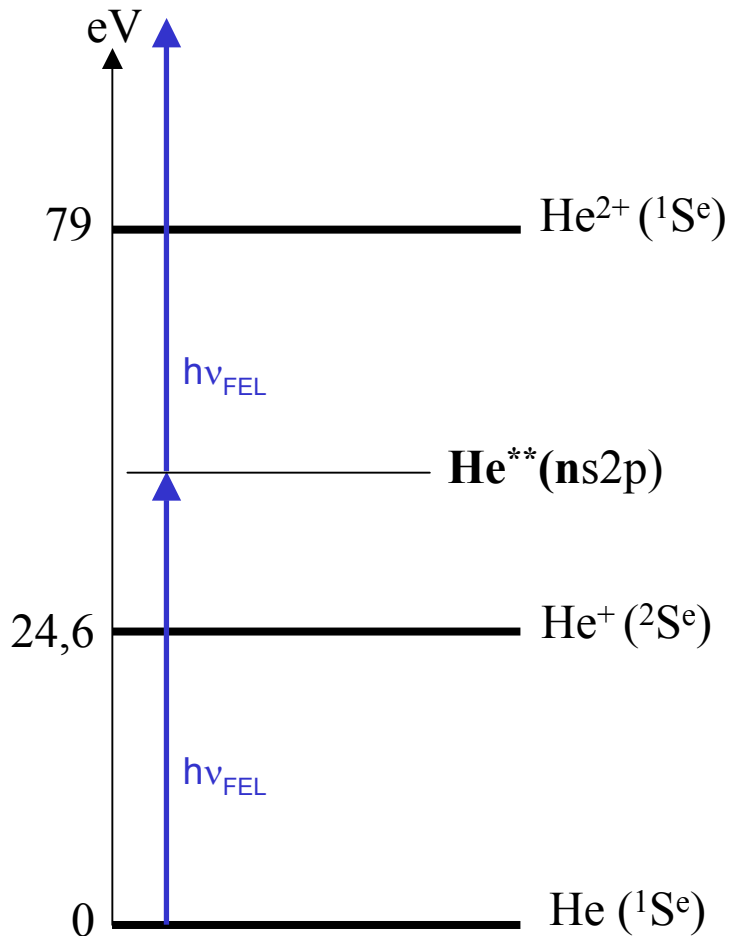


- Two Photon Direct Double Ionisation
- **Sequential Double Ionisation**

E_{exc} (eV)	$h\nu_{\text{FEL}}$ (eV)	Laser Harmonic	Undulator Harmonic
6	60,44	13	3
15,32	69,74	15 9	3 5

Changing the intensity from 10^{12} to 10^{15} W/cm²
 probe the orbitals relaxation time

2-Photon Double Ionisation FEL+FEL Complete Experiment

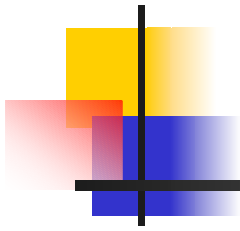
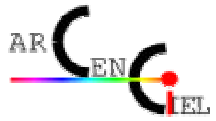


- Two Photon Direct Double Ionisation
- Sequential Double Ionisation
- **Resonant Double Ionisation**

E_{exc} (eV)	$h\nu_{XUV}$	Laser Harmonic	Undulator Harmonic
42 "2s2p"	60,14	13	3
60 "3s2p"	69,87	15 9	3 5

Tuning λ_{laser} by a few nm

→ select Direct Resonant Double Ionisation

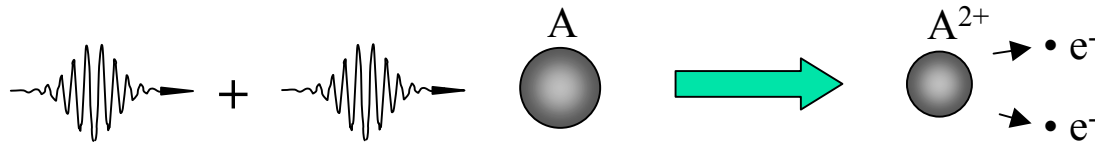


The end...

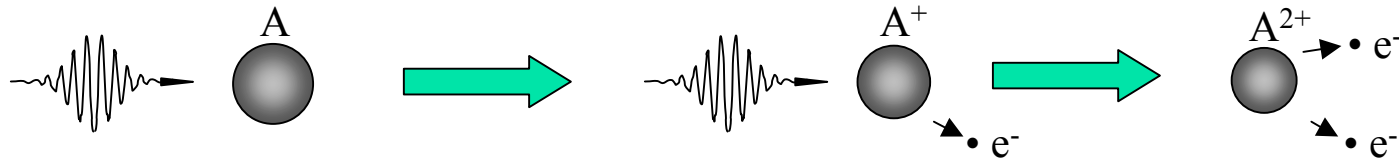
Two-Photon Double Ionisation

Physical processes

Direct (1 or 2 colors)



Sequential (dynamic depending on the field strength)



Re-scattering (strong laser field)

