polarization plane ($\phi_e = 90°$ or $270°$) when the molecular axis is perpendicular to the light propagation axis ($\chi = 90°$).[51]

The MP method has been benchmarked using the prototype NO DPI reaction corresponding to ionization of the 4σ inner-valence molecular orbital of the NO(X,$^2\Pi$) molecule (eqn (5)), previously studied,[11,45,47] which possesses fingerprint properties to act as an efficient "polarimeter", and is very well adapted to measure the polarization state of HHs composing an APT, as discussed in Section 4.

$$NO(^2\Pi,4\sigma^2 5\sigma^2 1\pi^4 2\pi^1) + h\nu \rightarrow NO^+(c^3\Pi,(4\sigma)^{-1}) + e \rightarrow N^+(^3P) + O(^3P) + e \quad (5)$$

Reaction (5) is the dominant DPI process for the studied XUV photon energies due to a strong shape resonance centered around 30 eV. Dissociation of the $NO^+(c^3\Pi)$ state is prompt relative to the rotational period and satisfies the conditions of axial recoil as validated by the detailed comparison of measured and computed angular anisotropies.[45,47] Both the asymmetry parameter β_{N^+} characterizing the ion fragment emission anisotropy and the MF circular dichroism parameter take significant values ($\beta_{N^+} \approx 1$ and CDAD ranging between 0.5 and 1), which correspond to favorable conditions for the extraction of the s_1, s_2, s_3 Stokes parameters.

Selecting as an example a polarization state, labelled *S*, similar to those reported in ref. 11 for a photon energy $h\nu = 23.65$ eV, Fig. 1 displays the key features for the extraction of s_1 and s_2, while Fig. 2 illustrates the MF circular dichroism and summarizes the extraction of s_3 leading to the full polarization ellipse.

Beside the three Stokes parameters, the polarization state can also be characterized by the parameters of the polarization ellipse which describes the polarized component of the light, *i.e.*, the orientation (ψ) and ellipticity (ε), and the degree of polarization *P*.[1] The (ψ, ε, *P*) quantities are related to the normalized s_1, s_2, s_3 Stokes parameters as follows:

$$\tan 2\psi = \frac{s_2}{s_1}, \quad \varepsilon = \tan \chi \text{ with } \sin 2\chi = \frac{s_3}{\sqrt{{s_1}^2 + {s_2}^2 + {s_3}^2}} \text{ and } P = \sqrt{{s_1}^2 + {s_2}^2 + {s_3}^2}$$

$s_4 = 1 - \sqrt{s_1^2 + s_2^2 + s_3^2} = 1 - P$represents the degree of unpolarized light.

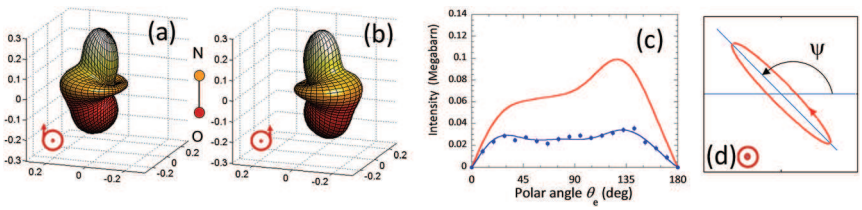

Fig. 2 Illustration of the MF circular dichroism at $h\nu = 23.65$ eV measured on the DESIRS beamline using circularly polarized light:[45] 3D $I_{90°}(\theta_e,\phi_e)$ MFPADs for $\chi = 90°$ induced by (a) RHC ($s_3 = +1$, helicity −1) and (b) LHC ($s_3 = -1$, helicity +1) polarized light. (c) Extraction of the s_3 Stokes parameter for the *S* polarization state: the measured $-s_3 \times F_{11}(\theta_e)$ function is shown (blue: dots and Legendre polynomial line fit); the $s_3 = -0.35 \pm 0.01$ value is obtained here as the ratio between the blue curve and the reference F_{11} function (red), corresponding to an ellipticity $\varepsilon = -0.2 \pm 0.01$. (d) Full polarization ellipse for the *S* state, resulting from the measured s_1, s_2, s_3 parameters.