

Contents

Abstract (English/Français)	i
List of figures	ix
List of tables	xi
Introduction	1
1 Magnetism of surface adsorbed atoms	5
1.1 Origin of magnetism in free atoms	5
1.2 Atom in a crystal field	6
1.2.1 Crystal field Hamiltonian	7
1.2.2 Magnetic levels in C_{3v} and C_{6v} crystal field symmetry	8
1.2.3 Quantum tunneling of magnetization in lanthanide atoms	10
1.2.4 Scattering with electrons and phonons in lanthanide atoms	11
1.3 Atom in a magnetic field	12
2 Methods	15
2.1 XAS and XMCD spectroscopy	15
2.1.1 Transition probability	15
2.1.2 Dipole selection rules	17
2.2 XMLD spectroscopy	17
2.3 Experimental aspects	18
2.3.1 Spectral analysis	18
2.3.2 Experimental setup and measurements	20
2.3.3 Sample preparation	21
2.4 Multiplet calculations	23
2.5 Scanning Tunneling Microscopy	24
3 Dy atoms on graphene/Ir(111)	25
3.1 Moiré pattern of graphene/Ir(111)	25
3.2 STM measurements of Dy on graphene/Ir(111)	26
3.2.1 Disordered Dy on graphene/Ir(111)	26

3.2.4 Dy monomers and dimers	30
3.3 XMCD measurements for Dy atoms on graphene/Ir(111)	32
3.3.1 Magnetism of Dy atoms on graphene/Ir(111)	32
3.3.2 Magnetic lifetime of Dy atoms on graphene/Ir(111)	36
3.4 Multiplet calculations for Dy atoms on graphene/Ir(111)	38
3.5 Steps in Dy hysteresis	42
3.6 Temperature dependence of Dy magnetic lifetime	44
3.7 Coverage dependent measurements	44
3.7.1 Coverage dependence of Dy XAS spectra	44
3.7.2 Coverage dependence of Dy magnetization curve	47
3.8 Exposure time dependence of Dy XAS spectra	48
3.9 Coverage calibration	48
4 Dy on Ir(111) and several decoupling substrates	51
4.1 Dy atoms on Ir(111)	51
4.2 Dy on graphene/Cu foil	53
4.2.1 Preparation of graphene/Cu substrate	53
4.2.2 Magnetism of Dy atoms on graphene/Cu foil	54
4.3 Dy on graphene/Ru(0001)	57
4.3.1 Properties of graphene/Ru(0001)	57
4.3.2 Magnetism of Dy atoms on graphene/Ru(0001)	57
4.4 Dy on HOPG	60
4.4.1 Properties of HOPG	60
4.4.2 Magnetism of Dy atoms on HOPG	61
4.4.3 Magnetic lifetime of Dy atoms on HOPG	63
4.5 Dy on <i>h</i> -BN/Ir(111)	64
4.5.1 Properties of <i>h</i> -BN	64
4.5.2 Magnetism of Dy atoms on <i>h</i> -BN/Ir(111)	64
5 Magnetism of Nd, Ho, Er and Tb on graphene/Ir(111)	69
5.1 Nd on graphene/Ir(111)	69
5.2 Ho on graphene/Ir(111)	73
5.3 Er on graphene/Ir(111)	77
5.4 Tb on graphene/Ir(111)	80
5.5 4 <i>f</i> occupation of lanthanides on graphene/Ir(111)	84
5.6 Magnetic stability of lanthanides on graphene/Ir(111)	84
5.7 Magnetic lifetime of lanthanides on graphene/Ir(111)	85
5.8 Sensitivity to contamination of lanthanides on graphene/Ir(111)	86
5.8.1 Exposure time dependence of Nd XAS spectra	86
5.8.2 Exposure time dependence of Ho XAS spectra	88
5.8.3 Exposure time dependence of Er XAS spectra	88
5.8.4 Exposure time dependence of Tb XAS spectra	91
5.9 Sum rules for lanthanide atoms	91

6 Co atoms on hexagonal boron nitride	95
6.1 Co on <i>h</i> -BN	95
6.1.1 Co on <i>h</i> -BN/Ru(0001)	96
6.1.2 Co on <i>h</i> -BN/Ir(111)	100
6.2 Discussion	102
Conclusion and outlook	105
A Crystal field parameters	109
B Tunnel splitting $\Delta_{7,-8}$ for Dy on graphene/Ir(111)	113
Bibliography	124
Acknowledgements	125
Curriculum Vitae	127