

The Work of John Tate

J.S. Milne

Tate helped shape the great reformulation of arithmetic and geometry which has taken place since the 1950s.

Andrew Wiles.¹

This is an exposition of Tate’s work, written on the occasion of the award to him of the Abel prize. True to the epigraph, I have attempted to explain it in the context of the “great reformulation”.

Contents

1	Hecke L-series and the cohomology of number fields	3
1.1	Background	3
1.2	Tate’s thesis and the local constants	6
1.3	The cohomology of number fields	8
1.4	The cohomology of profinite groups	12
1.5	Duality theorems	13
1.6	Expositions	15
2	Abelian varieties and curves	15
2.1	The Riemann hypothesis for curves	15
2.2	Heights on abelian varieties	16
2.3	The cohomology of abelian varieties	18
2.4	Serre-Tate liftings of abelian varieties	21
2.5	Mumford-Tate groups and the Mumford-Tate conjecture	22
2.6	Abelian varieties over finite fields (Weil, Tate, Honda theory)	23
2.7	Good reduction of Abelian Varieties	24
2.8	CM abelian varieties and Hilbert’s twelfth problem	25
3	Rigid analytic spaces	26
3.1	The Tate curve	27
3.2	Rigid analytic spaces	28
4	The Tate conjecture	31
4.1	Beginnings	31
4.2	Statement of the Tate conjecture	32
4.3	Homomorphisms of abelian varieties	33
4.4	Relation to the conjectures of Birch and Swinnerton-Dyer	34

¹ Introduction to Tate’s talk at the conference on the Millenium Prizes, 2000.

4.5	Poles of zeta functions	35
4.6	Relation to the Hodge conjecture	37
5	Lubin-Tate theory and Barsotti-Tate group schemes	38
5.1	Formal group laws and applications	38
5.2	Finite flat group schemes	41
5.3	Barsotti-Tate groups (p -divisible groups)	42
5.4	Hodge-Tate decompositions	43
6	Elliptic curves	44
6.1	Ranks of elliptic curves over global fields	44
6.2	Torsion points on elliptic curves over \mathbb{Q}	44
6.3	Explicit formulas and algorithms	45
6.4	Analogues at p of the conjecture of Birch and Swinnerton-Dyer	45
6.5	Jacobians of curves of genus one	47
6.6	Expositions	48
7	The K-theory of number fields	48
7.1	K -groups and symbols	48
7.2	The group K_2F for F a global field	49
7.3	The Milnor K -groups	51
7.4	Other results on K_2F	52
8	The Stark conjectures	52
9	Noncommutative ring theory	56
9.1	Regular algebras	56
9.2	Quantum groups	57
9.3	Sklyanin algebras	58
10	Miscellaneous articles	58
	Bibliography	66
	Index	72

The American Mathematical Society gratefully acknowledges the kindness of Springer Verlag in granting permission to use the table of contents from J. S. Milne, "The Work of John Tate", *The Abel Prize 2008–2012* (Helge Holden and Ragni Piene, editors), pp. 259–340, Springer, Heidelberg, 2014.