Sage Dynamics Ref Card v3.0

(for Sage 8.1)

Rings and Fields

ZZ	integer ring	Zmod(m)	$\mathbb{Z}/m\mathbb{Z}$
QQ	rational field	QQbar	alg. clos. of QQ
RR	real field	CC	complex field
Qp(p)	p-adic field	Zp(p)	p-adic integers
QQ[]	polynomials	QQ[[]]	power series
GF(p)	prime field	GF(p^n,'v')	finite field

CyclotomicField(*n*)	$\mathbb{Q}(\zeta_n)$
FractionField(*ring*)	field of fractions
QuadraticField(d)	$\mathbb{Q}(\sqrt{d})$
NumberField(*poly*,'*var*',[*emb*])	number field
K.absolute_field()	—
K.degree()	$[K:\mathbb{Q}]$
K.extension(poly)	fld ext
QQ.range_by_height(bd)	iterator
K.elements_of_bounded_height(bd, [params])	
number_field_elements_from_algebraics(*pts*)	

Spaces and Schemes

A.<*vars*>=AffineSpace(*ring*,*dim*)	$\mathbb{A}^n$
P.<*vars*>=ProjectiveSpace(*ring*,*dim*)	$\mathbb{P}^n$
PP.<*vars*>=ProductProjectiveSpaces(*ring*,*dims*)	$\mathbb{P}^n \times \cdots \times \mathbb{P}^m$
WehlerK3Surface(*polys*)	—
S.affine_patch(i,[$\mathbb{A}$])	—
S.base_ring()	base ring S
S.change_ring()	change base ring
S.coordinate_ring()	coor. ring of S
S.defining_ideal()	—
S.defining_polynomials()	—
S.dimension()	rel. dim of S
S.gens()	vars of coord. ring
S.point_transformation_matrix([pts,pts])	find PGL element
S.projective_embedding([i,$\mathbb{P}$])	—
S.projective_closure([i,$\mathbb{P}$])	—
S.rational_points([bd,fld])	—
S.subscheme(*polys*)	subscheme of S
S.vars()	vars of coord. ring
S.variable_names()	vars as strings
S.weil_restriction()	restric. of const.

Dynamical System Initialization

DynamicalSystem(polys, [domain])	projective if no domain
DynamicalSystem_affine(polys, [domain])	
DynamicalSystem_projective(polys, [domain])	
f.as_dynamical_system()	End $\to$ DS

Periodic Behavior

f.dynatomic_polynomial([m,n])	—
Q.is_preperiodic(f)	—
Q.multiplier(f,n)	$(f^n)'(Q)$
Q.orbit_structure(f)	[tail,period]
f.periodic_points(n,[params])	—
f.rational_periodic_points([params])	—
f.rational_periodic_graph([params])	—
f.rational_preperiodic_points([params])	—
f.rational_preperiodic_graph([params])	—
f.possible_periods([params])	via good red.

Heights and Measures

Q.canonical_height(f,[params])	$\hat{h}_f(Q)$
f.critical_height()	$\sum_{c\in\text{Crit}} \hat{h}_f(c)$
Q.global_height([prec])	$h(Q)$
f.global_height([prec])	—
Q.green_function(v,[prec])	at v
f.height_difference_bound()	$\lvert h(Q) - \hat{h}_f(Q)\rvert$
f.local_height_arch(i,[prec])	at ∞

Critical Points

f.critical_points()	—
f.critical_subscheme()	—
f.critical_point_portrait()	—
f.critical_height()	$\sum_{c\in\text{Crit}} \hat{h}_f(c)$
f.is_postcritically_finite()	—
f.wronskian_ideal()	crit locus

Cyclic Structures

f.all_rational_preimages(*points*)	—
f.cyclegraph() $\boxed{\mathbb{F}_q}$	digraph
Q.orbit_structure(f) $\boxed{\mathbb{F}_q}$	[tail,per]
Q.rational_preimages(f)	—
Q.rational_connected_component(f)	—

Rational Functions

f.dynamical_degree()	—
f.degree_sequence()	deg. of iterates
f.indeterminacy_locus()	—
f.indeterminancy_points()	if fin. many

Functions

f[i]	ith coord
f.automorphism_group()	$\{\phi : f^\phi = f\}$
f.autmorphism_group()	$\text{Hom}(f,f)$
f.base_ring()	—
f.change_ring()	—
P.chebyshev_polynomial(k,*kind*)	
f.codomain()	—
f.conjugate(ϕ)	$\phi^{-1}\circ f\circ\phi$
f.conjugating_set(g)	$\text{Hom}(f,g)$
f.defining_polynomials()	—
f.degree()	—
f.dehomogenize(k)	—
f.domain()	—
f.homogenize(k)	
f.is_morphism()	—
f.normalize_coordinates()	remove gcd
f.nth_iterate(Q,n)	$f^n(Q)$
f.nth_iterate_map(n)	f^n
P.Lattes(E,m)	create Lattès map
f.orbit(Q,[m,n])	$\{f^m(Q),\ldots,f^n(Q)\}$
f.primes_of_bad_reduction()	—
f.resultant()	—
f.scale_by(t)	$t\cdot f$
f.specialization()	subs value of param

Points

Q[i]	ith coord
Q.change_ring()	—
Q.clear_denominator()	—
Q.codomain()	ambient space
Q.dehomogenize(i)	—
Q.domain()	base ring
Q.homogenize(i)	—
Q.normalize_coordinates()	remove gcd
Q.nth_iterate(f,n)	$f^n(Q)$
Q.orbit(f,(m,n))	$[f^m(Q),\ldots,f^n(Q)]$
Q.scale_by(t)	$t\cdot Q$

Iteration

f.nth_iterate(Q,n)	$f^n(Q)$
f.nth_iterate_map(n)	f^n
f.orbit(Q,[m,n])	$[f^m(Q),\dots,f^n(Q)]$
f.rational_preimages(Q,k)	$f^{-k}(Q)$

Moduli Spaces

f.is_polynomial()	has tot. ram. fixed pt.
f.is_PGL_minimal()	
f.is_conjugate(g)	$g \stackrel{?}{=} f^\phi$
f.normal_form()	$x^n + a_{n-2}x^{n-2} + \cdots + a_0$
f.minimal_model()	min resultant f^ϕ
f.multiplier_spectra(n,[params])	$\{\lambda_f(Q) : Q \in \mathrm{Per}_n\}$
f.sigma_invariants(n,[params])	$\{\sigma_i(\lambda_f(Q)) : Q \in \mathrm{Per}_n\}$

Finite Fields

f.cyclegraph()	iteration digraph
Q.orbit_structure(f)	[tail,period]

Mandelbrot and Julia Sets

external_ray(v)	list or single angle
mandelbrot_plot([params])	for z^2+c
julia_plot([params])	for z^2+c

Miscellaneous / Help

_	last output
%time	execution time
timeit('*cmd*',number=#)	time multiple iterations
s.<*tab*>	show all cmds on s
s.*cmd*?	info about cmd on s
set_verbose(None)	disable warnings
load(''*path to file*'')	load code file
copy(obj)	—
latex(obj)	—
all(*list of bool*)	—
any(*list of bool*)	—
sum(*list*)	—
max(*list*)	—
isinstance(f, *type*)	check for type
preparser(*bool*)	on/off notebk preparsing

Matrices

matrix(K,n,m,*list*)	create matrix
matrix(K,*list of lists*)	create matrix
M.charpoly()	—
M.determinant()	—
M.height()	global height
M.inverse()	—
M.LLL([args])	LLL reduced lattice
M.minors(k)	dets of $k \times k$ minors
M.rank()	—

Polynomial Rings

R.<a,b>=PolynomialRing(K,2)	poly ring over K
R.<a>=PolynomialRing(K)	univar poly ring
R.<a>=PolynomialRing(K,1)	multivar poly ring
R.gen(k)	kth variable
R.gens()	all variables
R.hom(*im_gens*,S)	Hom(R,S)
R.ideal(polys)	—
I.dimension()	krull dim of R/I
I.elimination_ideal(*vars*)	—
I.gens()	—
I.groebner_basis()	—
I.is_prime()	—
I.is_maximal()	—
I.is_principal()	—
I.is_one()	—
I.primary_decomposition()	—
I.radical()	—
I.ring()	R
I.variety()	rat pts of dim 0
I.vector_space_dimension()	of R/I
F.monomial_coefficient(*mon*)	base ring element
F.polynomial(x)	make univariate
F.subs(*dict*)	substitution
F(*tuple*)	substitution
F.coefficient(*mon*)	poly element
F.coefficients()	—
list(F)	list of (coeff,mon)
F[*list*]	coeff of mon with exp *list*
F.dict()	dict of mon:coef via exp
F.lift(I)	coeff of gens of I to get F

Algebraic Geometry

S.Chow_form()	associated Chow form
S.coordinate_ring()	—
S.defining_ideal()	—
S.defining_polynomials()	—
S.degree()	from lc of hil poly
S.dimension()	relative dimension
S.intersection(T)	—
S.intersection_multiplicity(T,Q)	Serre's Tor
S.irreducible_components()	—
S.is_smooth()	—
S.Jacobian()	Jacobian ideal
S.projective_closure([$\mathbb{P}$])	—
S.rational_points([bd])	—
S.subscheme(*ideal*)	—
S.veronese_embedding(d)	—
S.weil_restriction()	—
S*T	$S \times T$
S**n	$S \times \cdots \times S$
I.radical()	radical ideal

PP.components()	—
PP.dimension_components()	list of dims
PP.segre_embedding([*codomain*])	—

C.arithmetic_genus()	—
C.genus()	—
C.is_complete_intersection()	—
C.is_ordinary_singularity(Q)	—
C.is_transverse(D,Q)	—
C.tangents(Q)	

 Thanks to ICERM for hosting us while version 1.0 was written.