Contents

1	Intr	oduction	1		
	1.1	Motivation	1		
		1.1.1 Active Matter	1		
		1.1.2 Epithelial tissues as active systems	2		
		1.1.3 Austrolebias nigripinnis: early developmental stages	3		
		1.1.4 Apical cellular contractions	6		
	1.2	Computational models of epithelial tissues	7		
		1.2.1 Vertex model	7		
		1.2.2 Cellular Potts model	10		
	1.3	Theoretical models	11		
		1.3.1 Vectorial activity	11		
		1.3.2 Active gels \ldots	11		
	1.4	Research aims and objectives	12		
	1.5	Thesis overview	12		
2	Our	model: its ingredients	14		
	2.1	Vertex model for a two-dimensional planar tissue	14		
	2.2	Active and fluctuating vertex model, with plasticity or memory	15		
	2.3	Fluctuating tissues with memory and impulsive activity	16		
	2.4	Active contraction pulses	17		
3	Instabilities for tissues subject to cellular activity or applied stresses 1				
	3.1	Tissue under cell activity	20		
	3.2	Short and long time scales	23		
	3.3	Tissue under pre-stress	25		
	3.4	Anisotropic pre-stresses	28		
	3.5	Examples of non-diagonal μ -matrices	30		
4	Geo	metrical characterization of active contraction pulses in epithelial cells			
-	usin	ig the vertex model	32		
	4.1	Isolated active hexagonal cell	33		
	4.2	Active cell embedded in a tissue	34		
		4.2.1 Linear response	36		
		4.2.2 Non-linear dynamic response	38		
		4.2.3 Plasticity	41		
5	App	blication: Austrolebias nigripinnis pre-epiboly stage	45		

	5.1	Experimental information	45	
	5.2	Computational model	50	
		5.2.1 Vertex model geometrically constrained	50	
		5.2.2 Pre-epiboly cellular rearrangements and active contraction pulses	52	
	5.3	Fist stage of optimization: pseudo-passive system	52	
	5.4	Second stage of optimization: active events	54	
		5.4.1 Active cell C37 \ldots	55	
		5.4.2 Active cell C44 \ldots	57	
		5.4.3 Active cell C32 \ldots	59	
		5.4.4 All active cells	61	
	5.5	Third stage of optimization: Simplified model	62	
6	From discrete to continuum			
	6.1	Discrete stress tensor	65	
	6.2	M tensor as a field \ldots	67	
	6.3	Elastic stress tensor	68	
	6.4	Centered active force: steady state	71	
		6.4.1 Comparison with simulations	74	
	6.5	Centered active force: temporal evolution	82	
		6.5.1 Comparison with simulations	82	
7	Structure factors in active tissues			
	7.1	Static structure factor: velocity field	85	
	7.2	General considerations for the simulations	86	
	7.3	Structure factors of cellular fields: S_R , S_Q and S_{ϕ}	89	
	Con	nclusions	103	
Bibliography				
	T 7			
A	Ver	tex model: Equations of motion	111	
В	Mo	dels of viscoelasticity	115	
		B.0.1 Maxwell model	115	
		B.0.2 Kelvin model	116	
\mathbf{C}	Ene	ergy expressions for fluctuation tissues	117	
	C.1	Tissue under cell activity	117	
	C.2	Tissue under stress	118	
D	Ver	tex model: Isolated active hexagonal cell	121	
\mathbf{E}	Ver	tex active model: Linear order equations of motion	125	