

Numerical study of a swirl generator with two tangential inlets

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Introduction

- Experimental databases contribute effectively in the development of CFD.
- Our objective is to create an experimental database on the interaction between a bubble swarm and a simple swirling flow.
- A key element of the needed experimental loop is a swirl generator.
- This numerical study assesses the swirling flow generated by two tangential flows injected into an axial flow.

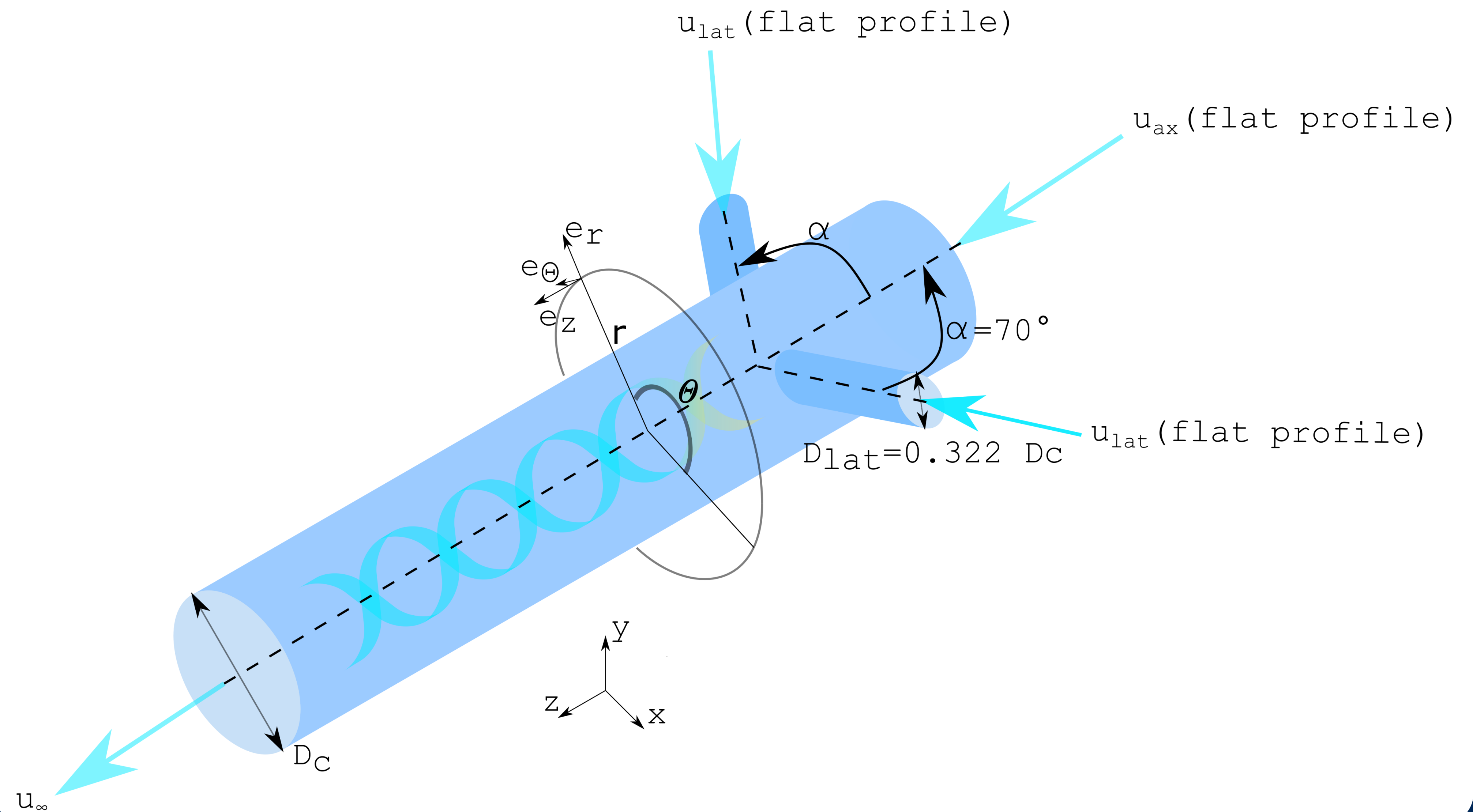
Definitions

$$r^* = \frac{2r}{D_c} ; \quad z^* = \frac{z}{D_c} ; \quad Re_\infty = \frac{u_\infty D_c}{\nu}$$

$$\text{Flow rate ratio} : \beta_T = \frac{u_{lat} D_{lat}^2 \cos(\alpha)}{u_{ax} D_c^2 + u_{lat} D_{lat}^2 \sin(\alpha)}$$

$$\text{Swirl Number} : S = \frac{\int_0^{2\pi} \int_0^{R_c} r u_\theta u_z r dr d\theta}{R_c \int_0^{2\pi} \int_0^{R_c} r u_z^2 dr d\theta}$$

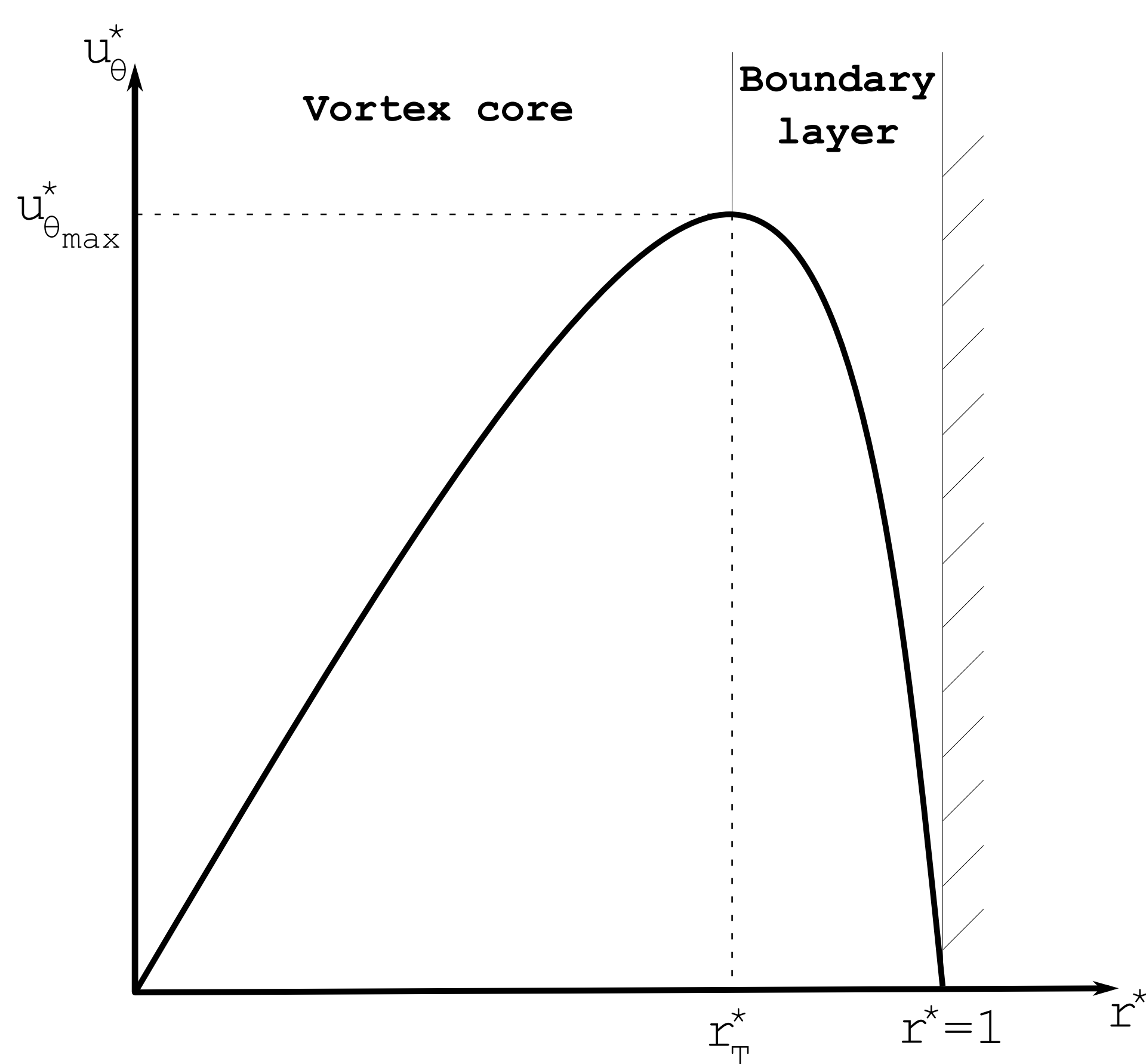
Simulated flow



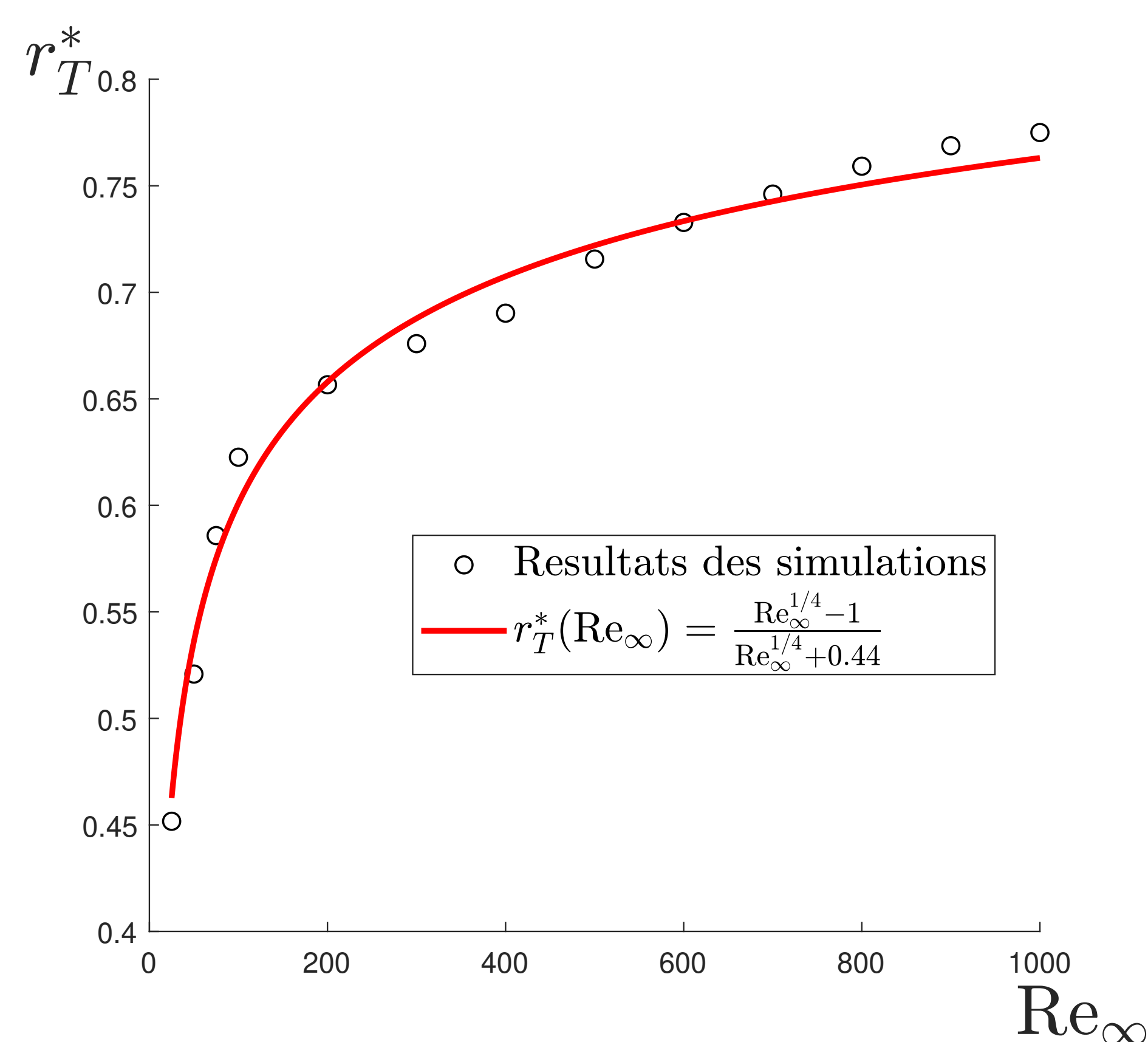
Orthoradial velocity

Two flow zones :

- Solid rotation in the vortex core.
- Boundary layer in the vicinity of the wall.



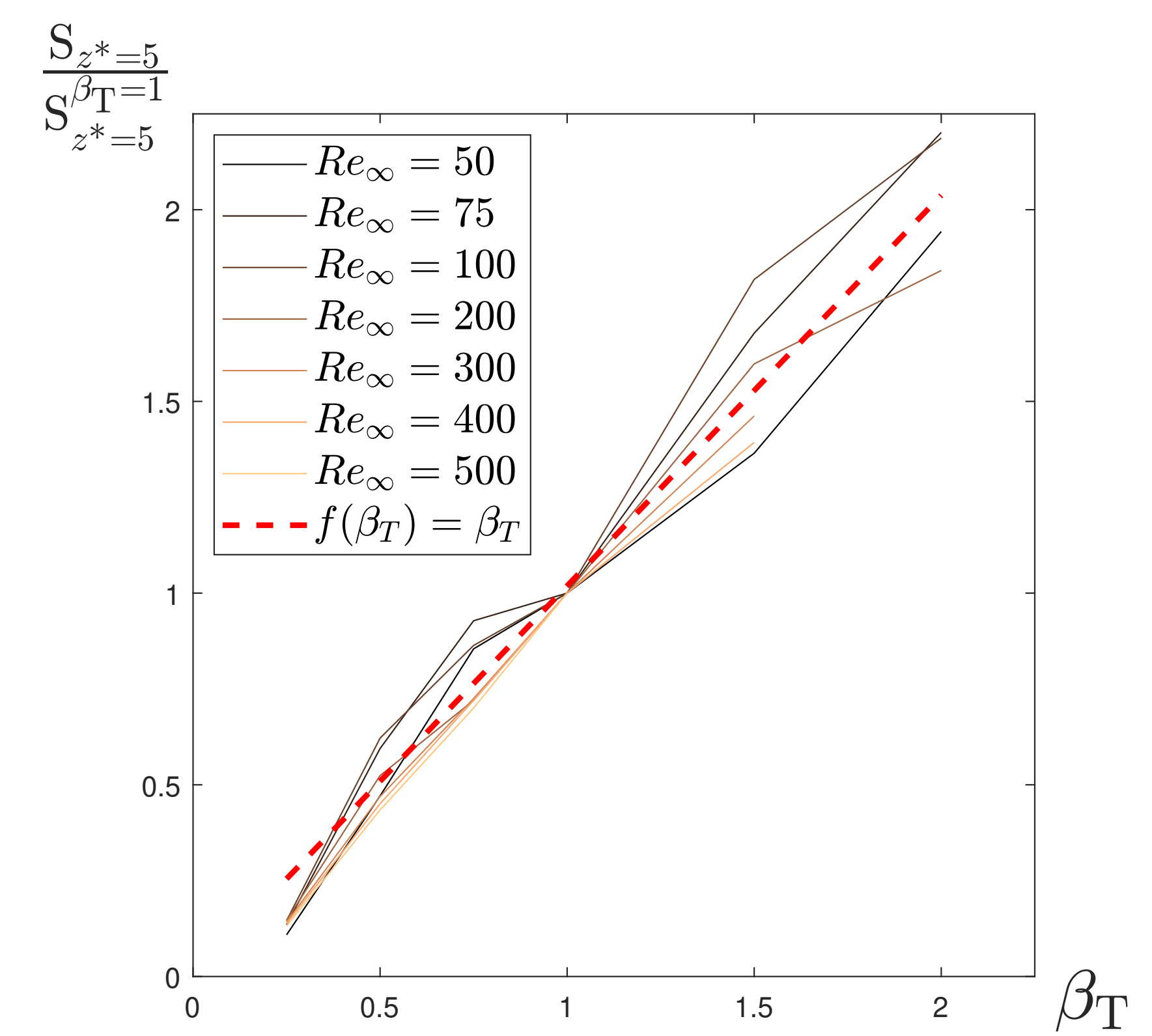
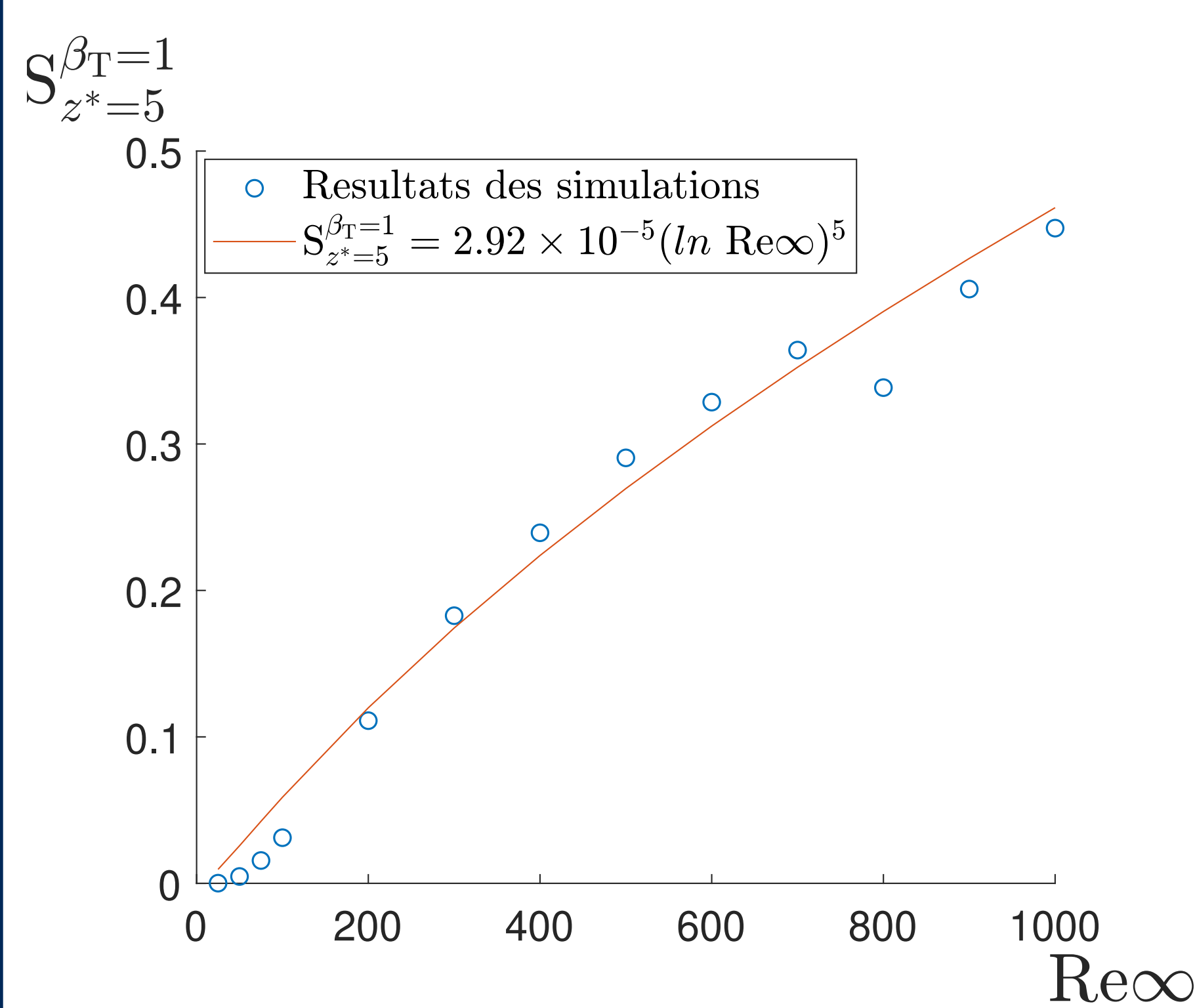
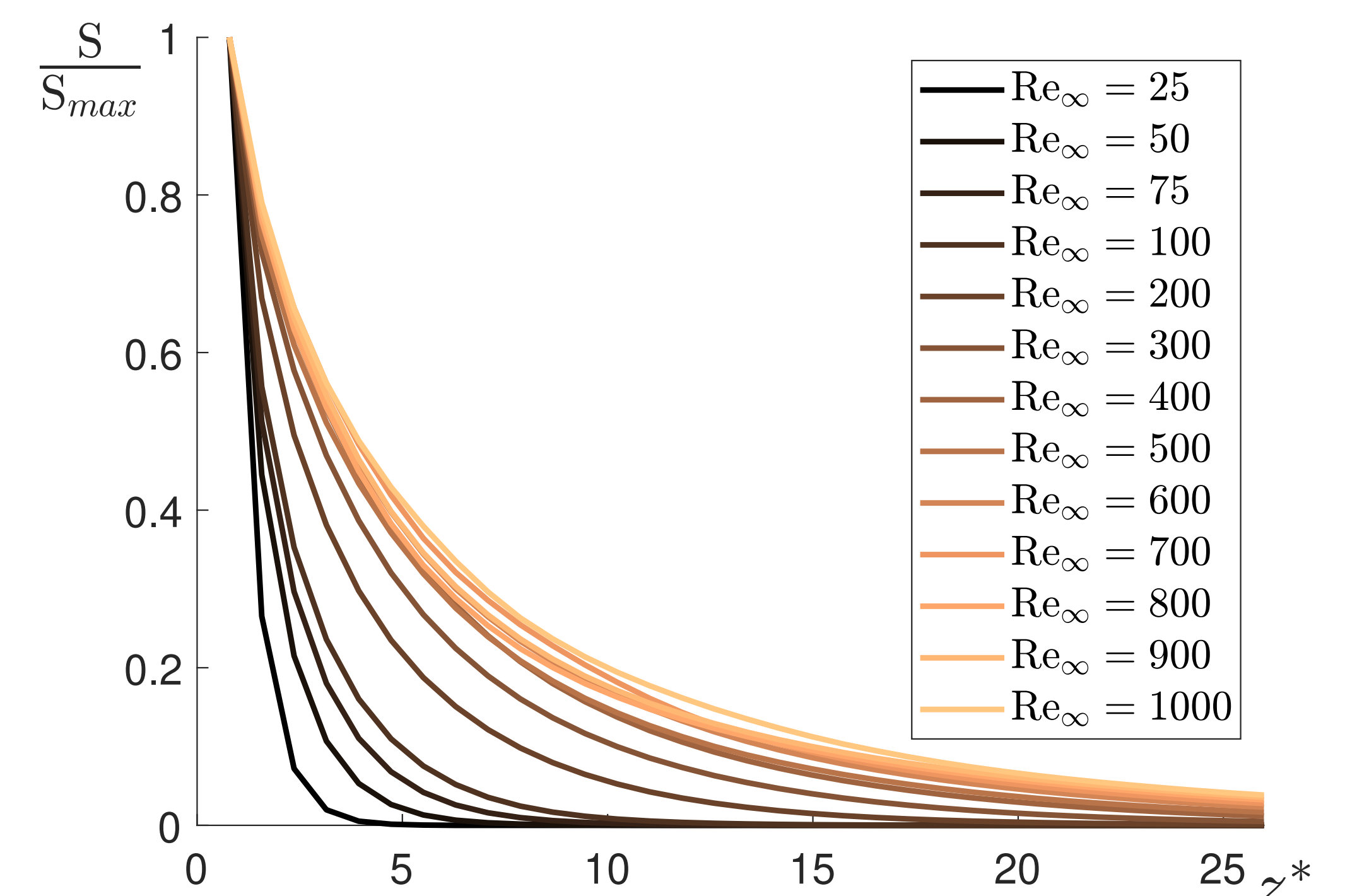
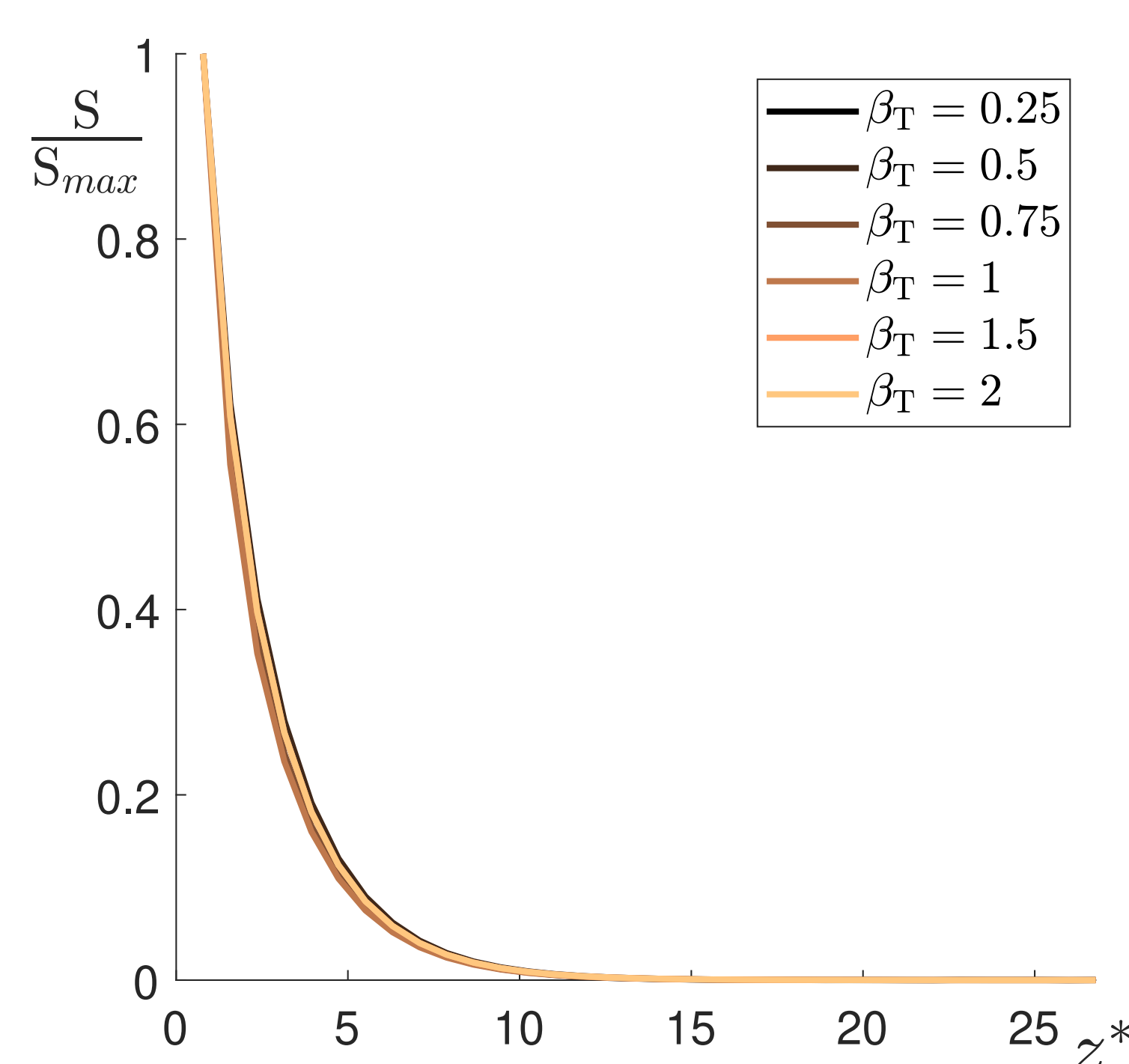
The vortex core radius increases with Re_∞ :



Swirl Number decay

According to the results below :

- The Swirl Number decreases exponentially along the pipe.
- The decay depends on Re_∞ and not on β_T .
- The resulting Swirl Number is proportional to β_T .



$$S(\beta_T, Re_\infty, z^*) \simeq 2.92 \times 10^{-5} \times \beta_T \left(\ln Re_\infty \right)^5 \exp\left(\frac{z^* - 5}{2.24 Re_\infty^{0.224} - 4.32} \right)$$

Acknowledgments

Conclusions

1. Two tangential injections in an axial flow generates a solid body rotation vortex.
2. The Swirl Number decays exponentially along the pipe.
3. The Swirl Number increases proportionally with the flow rate ratio β_T .