

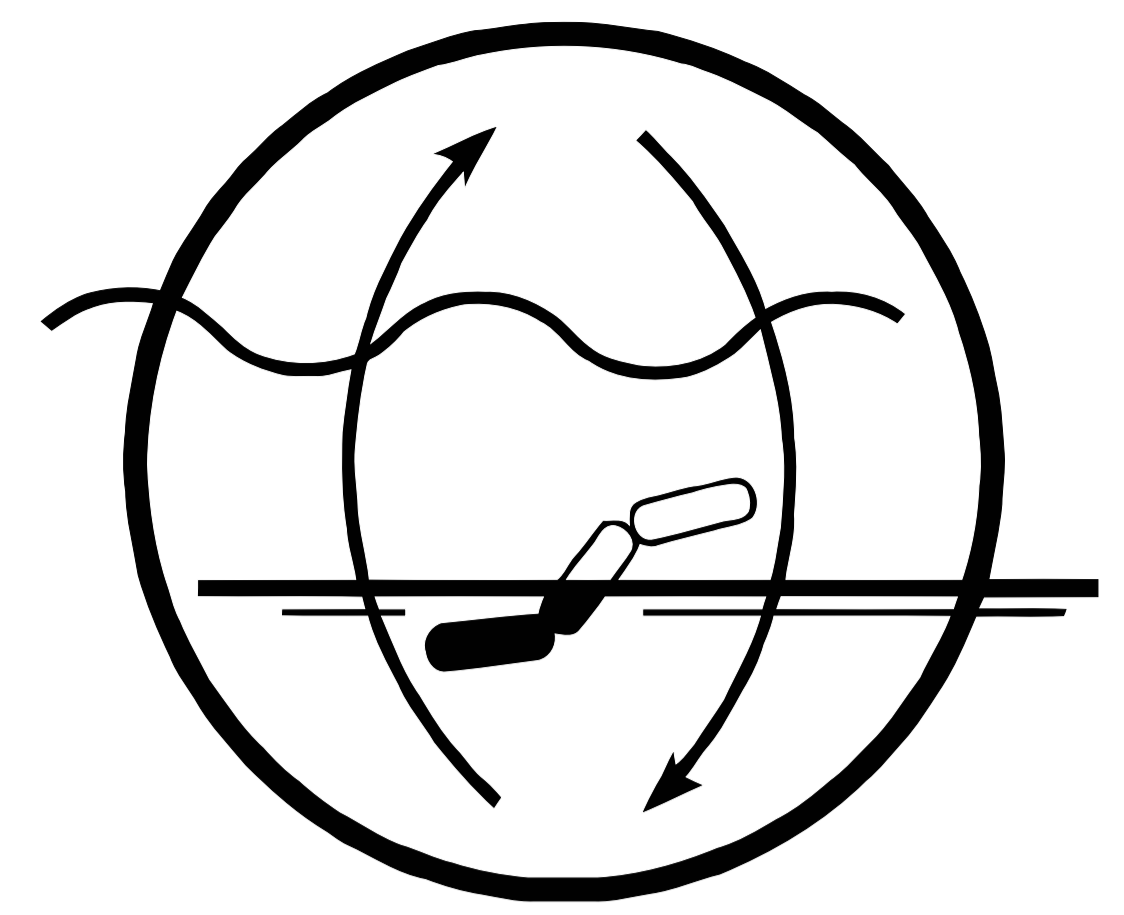


Tortuosity–porosity relation in the porous media flow

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The aim of this work was to check the tortuosity–porosity relation in a microscopic porous media model arranged as a collection of freely overlapping squares. We use the Lattice Boltzmann BGK model for calculation of the steady state low Mach number fluid flow. We propose simple calculation procedure that eliminates the need for using complicated, weighted averages introduced elsewhere [Kop97]. We show that by taking into consideration the finite-size effects along with the relaxation time we are able to reproduce an experimental law $T = 1 - p \cdot \log(\phi)$ proposed by Comiti et. al. [Com89].

Tortuosity in Porous Media

The tortuosity (T) in porous media is used in Kozeny's relation [Bea72]:

$$k = c_0 \frac{\phi^3}{T^2 S^2}. \quad (1)$$

We express the tortuosity as:

$$T = \frac{1}{L} \frac{\int_A u_y(x) \lambda(x) dx}{\int_A u_y(x) dx}, \quad (2)$$

where:

A arbitrary cross-section,

$\lambda(x)$ the length of the streamline cutting A at x ,

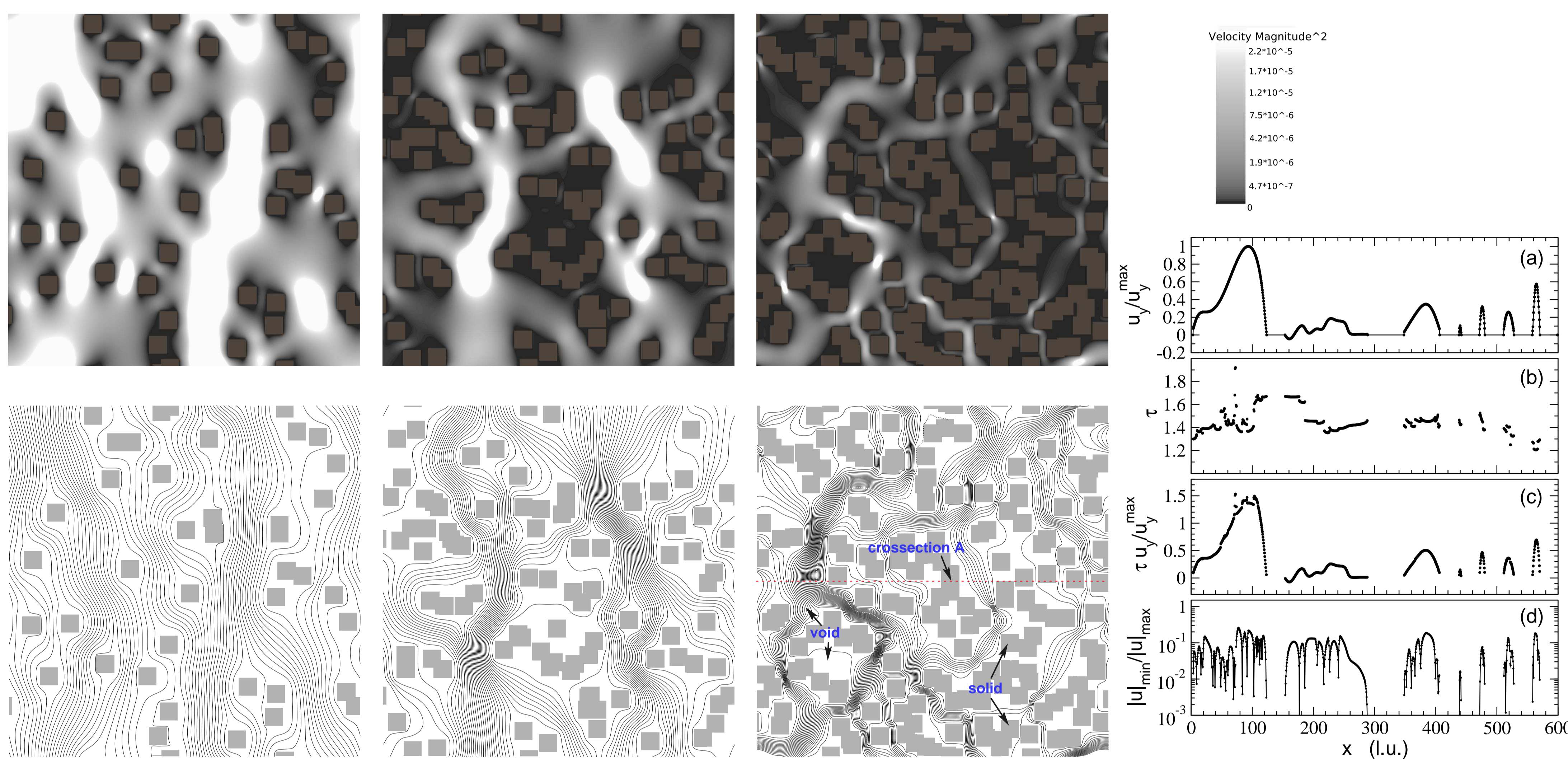
$u_y(x)$ the component of the velocity field at x normal to A .

Constant flux assumption:

$$u_y(x_j) \Delta x_j = \text{const}, \quad (3)$$

gives simplified expression for tortuosity:

$$T \approx \frac{1}{L} \frac{1}{N} \sum_{j=1}^N \lambda(x_j). \quad (4)$$

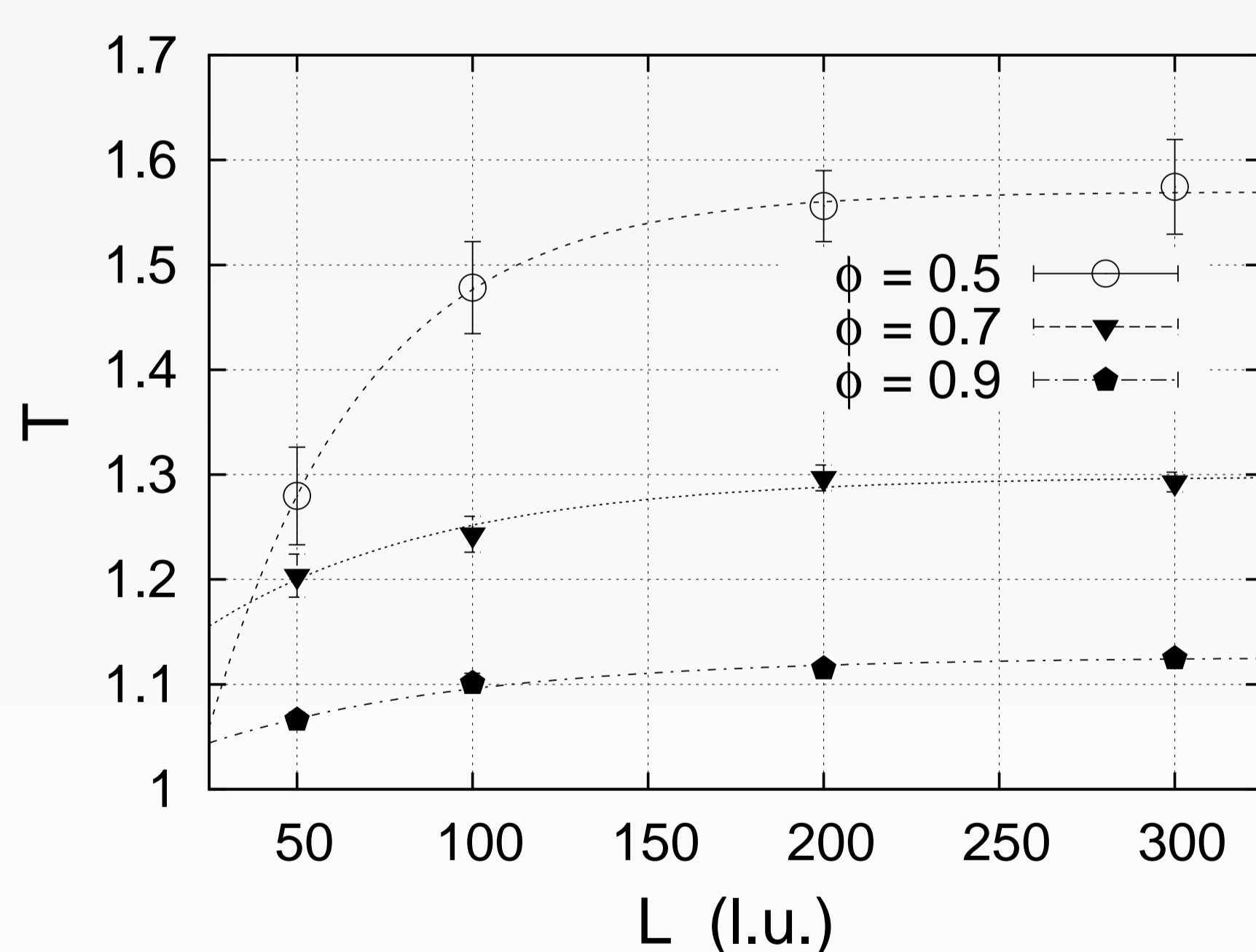


$\Phi = 0.9, T = 1.09$

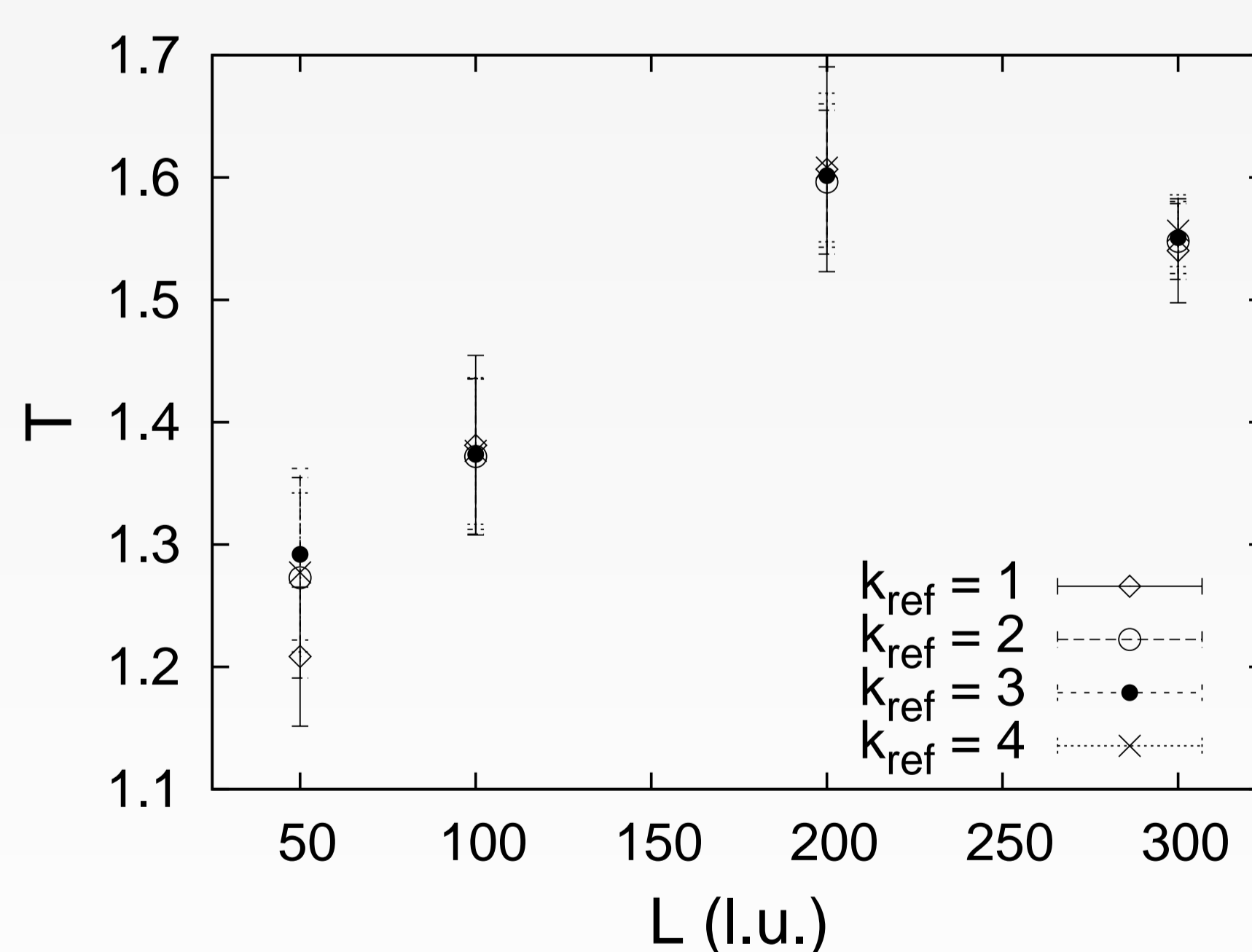
$\Phi = 0.8, T = 1.2$

$\Phi = 0.65, T = 1.45$

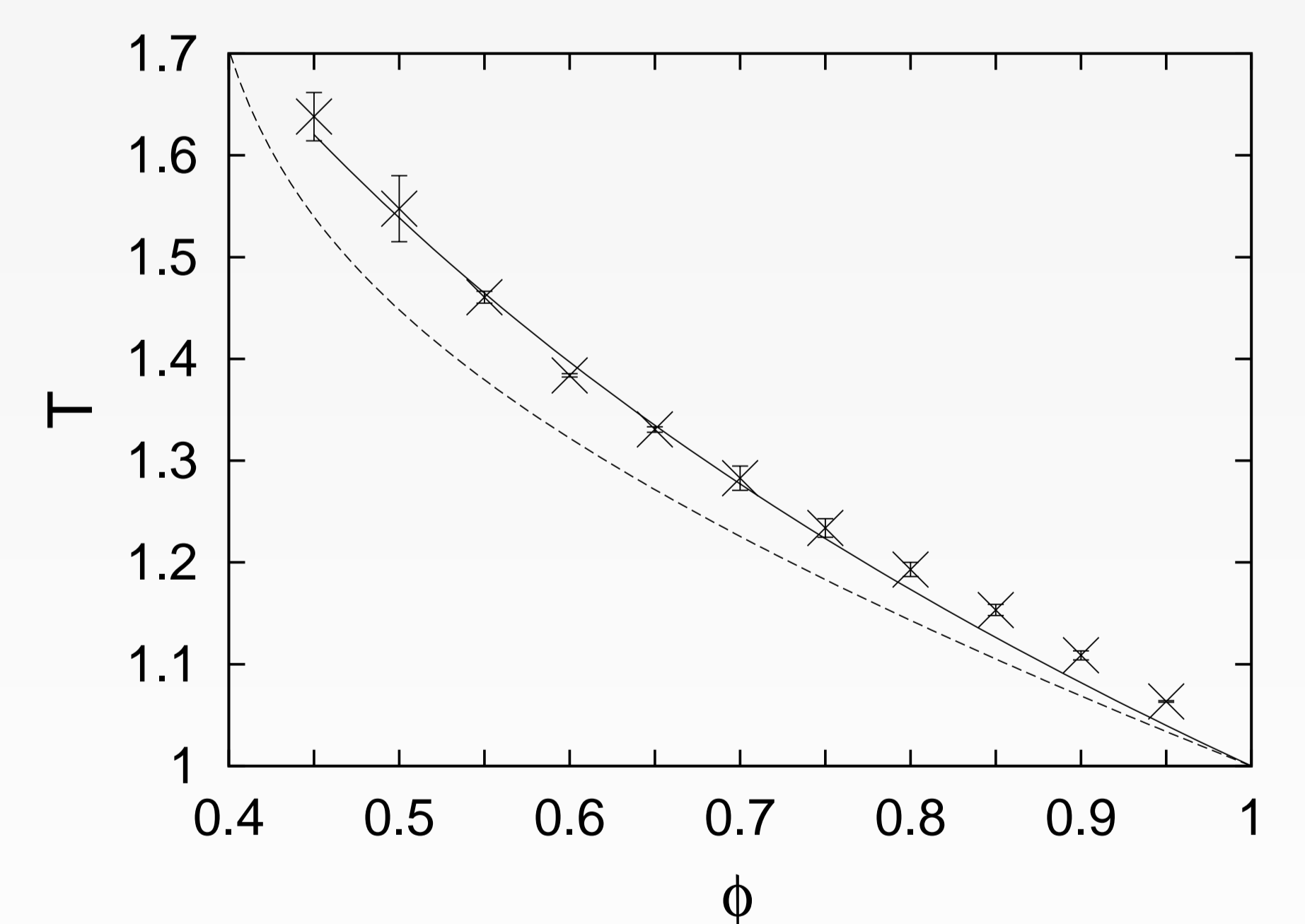
Quantities at cross section A.
($\tau(x) = \lambda(x)/L$ is local T)



Tortuosity T as a function of the system size L , averaged over 25 samples, for at three different porosities $\phi = 0.5, 0.7, 0.9$.



The dependency of T on the system size L for $\phi = 0.5$ at four different refinement levels k_{ref} . Each point represents an average over 9 samples.



$T(\phi)$ dependency. Our data (\times), relation by Koponen [Kop97] et al. (dashed line), logarithmic law by Comiti et al. [Com89] (solid line).

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