Stochastic for Material Scientists

Programming Project Report-2021

TECHNISCHE UNIVERSITÄT
BERGAKADEMIE FREIBERG

Die Ressourcenuniversität. Seit 1765.

Abrar Hyder Mohammed

Matriculation Number: 65092

Computational Material Science

I. Contents

II. Task 1

Given the realization of two random sets with dimensions 400 by 400 pixels

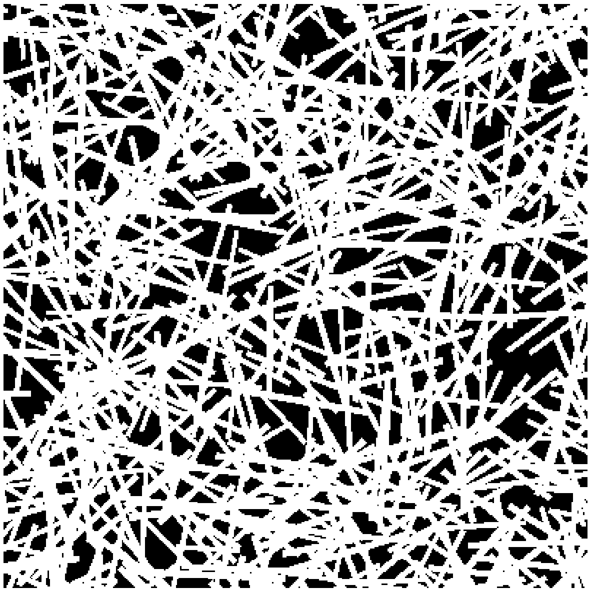


Figure 1

Figure 2

A. 1(a)

The key similarities or differences between these two realization sets are as follows:

The set-in fig(a) has following properties

- Homogenous
- Compact
- Non-convex

The set-in fig(b) has the following properties

- Non- convex
- Compact

Set 1 in fig(a) can be considered as random mosaic since it possesses following properties as follows

- Most of the cells overlap at their boundaries
- closed set
- The whole space is covered

B. 1(b)

First, second and third Minkowski functions for the first realization set

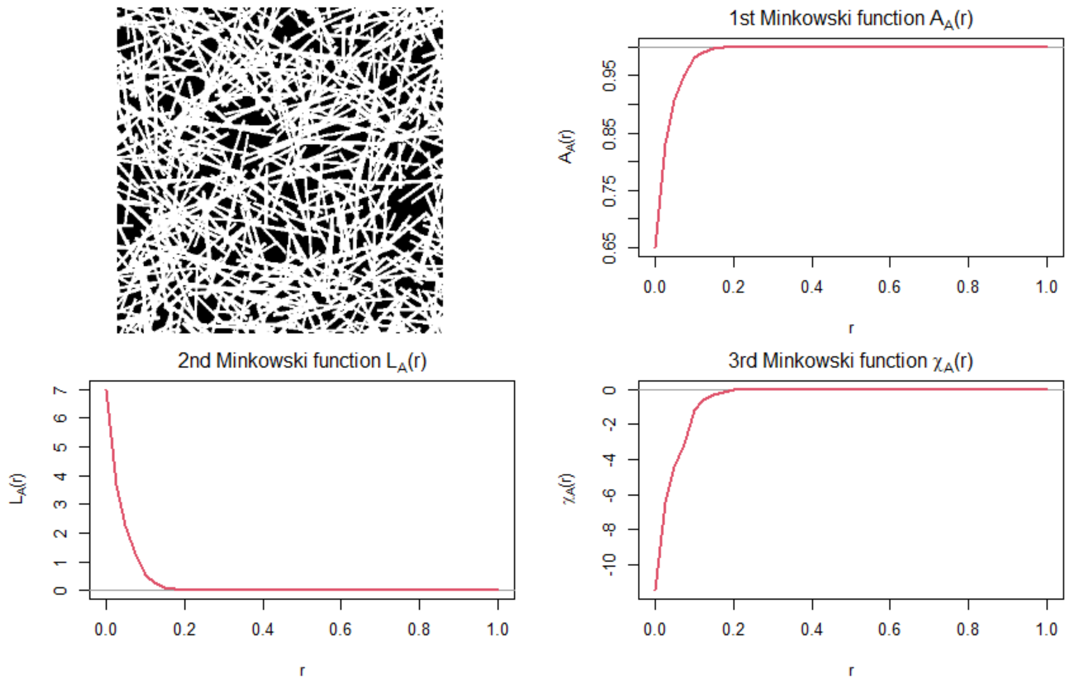


Figure 3

Similarly for the second realization set

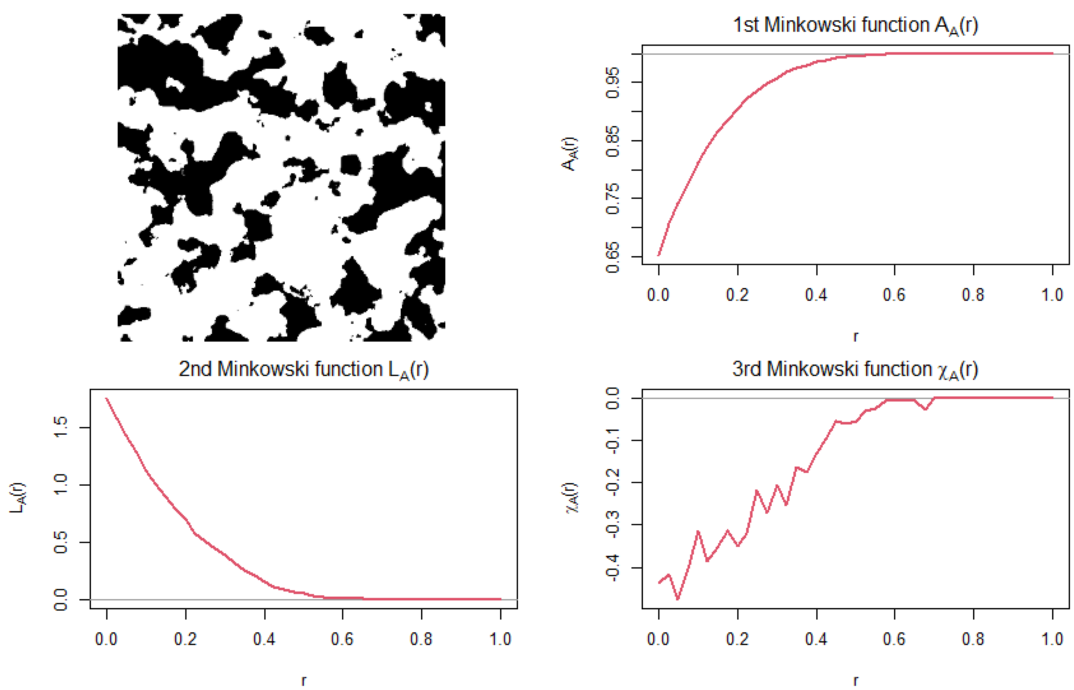


Figure 4

Finally the combined plots for both sets of realization

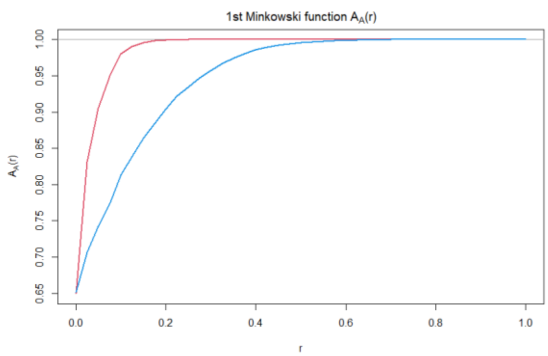


Figure 5 : $A_A(r)$

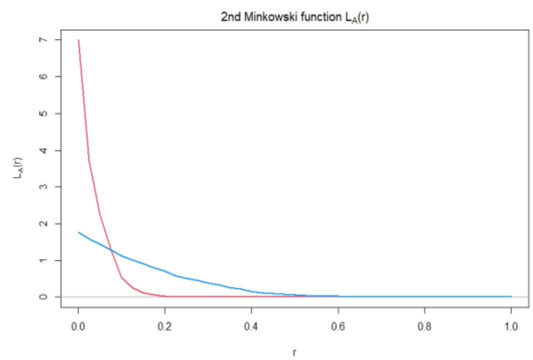


Figure 6: $L_A(r)$

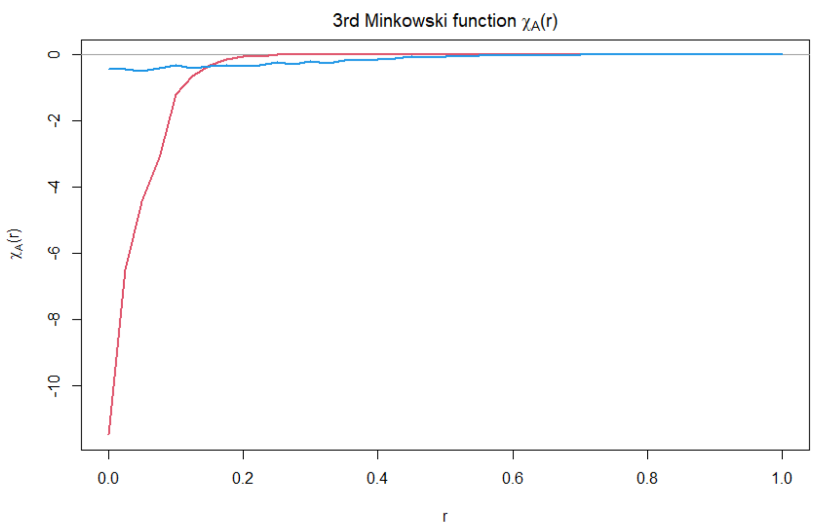


Figure 7: $X_A(r)$

C. 1(c)

The blue lines indicate the first set while the red line indicates the second set

- In both the cases A_A increases monotonically from r=0 to r=1 till the whole plane is covered.
- Since L_A depends on the roughness and size of the random set initially for small r (say r<0.3) L_A is considerably high in case of second set as it is inhomogeneous while compared to the first set of realization. Slowly its value tends to become zero as while growing it covers the void spaces.
- Since in 2D the Euler number is the difference of the number of connected components and number of holes. As there are comparatively less number of holes in first set compared to the second set it quickly tends to zero whereas in second set X_A first increases and then decreases to zero because of the together growing components and formation of new disconnected holes.

III. Task 2

A. 2(a)

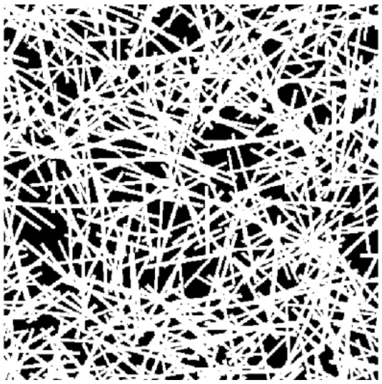


Figure 8 : Disc dia =1

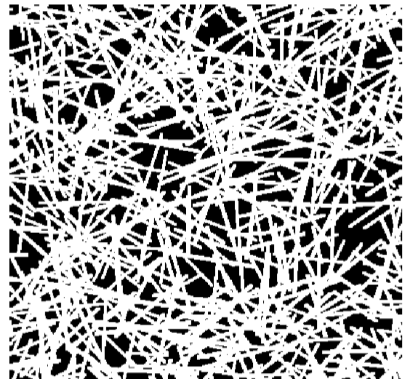


Figure 9 : Disc dia =1

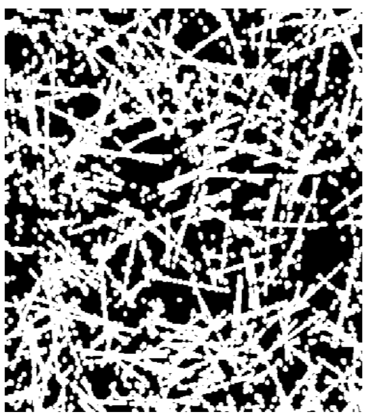


Figure 10: Disc dia =5

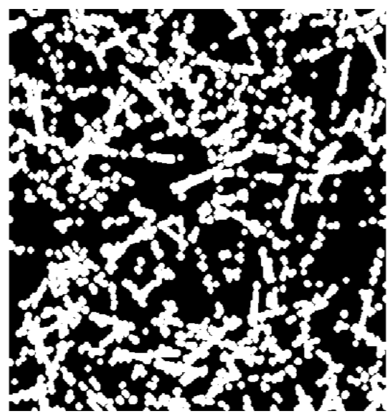


Figure 11: Disc dia =7

After applying morphological opening to set 1 realization my choice of b would be **disc diameter=7** . Because the considerable part of the rectangular grain vanishes for the first time at the size of 7. Therefore, the length of the shorter side of the rectangular grain would be **b= m. pixel length(s)=7.0.025=0.175mm**

B. 2(b)

In case of Person A with the values λ = 4.9, a= 2.5, b= 0.15 the p value reported was 0.652 which is greater than the α = 0.05. Therefore, the proposed model A is selected.

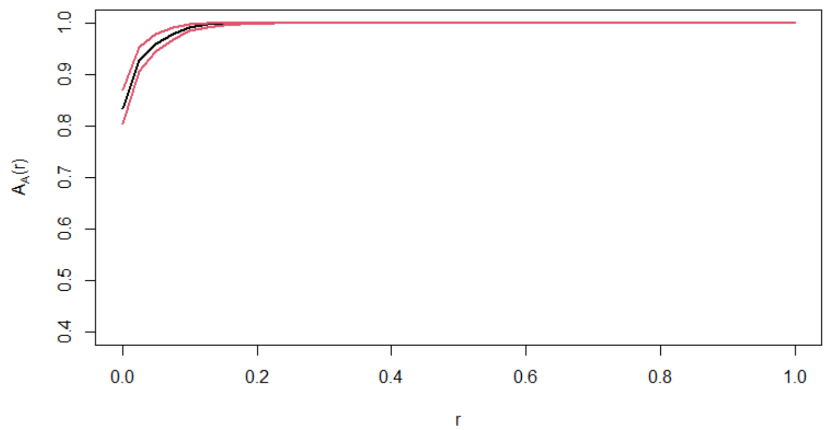


Figure 12

In case of Person B with the values λ = 4.8, a= 1.8, b= 0.13 the p value reported was 0.0035 which is less than the significance level α = 0.05. Therefore, the proposed model B must be rejected. It can clearly be stated from the figure that the model is not sufficiently good for the data as the data curve is somewhere outside the band between the envelope curves.

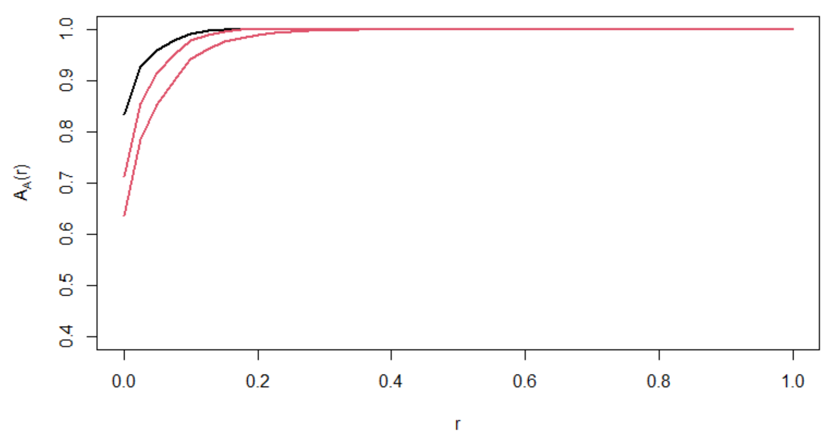
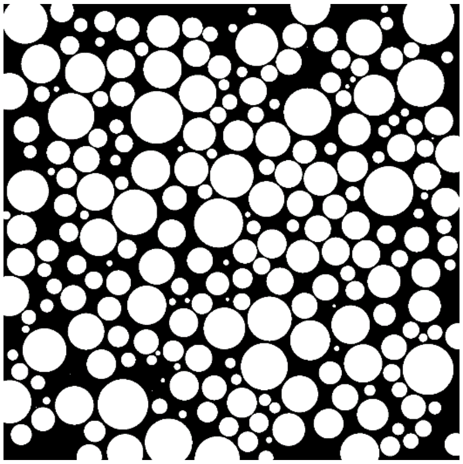


Figure 13

IV. Task 3

Given a random set realization of 1400 by 1400 pixels with pixel length spacing=0.001mm



A. 3(a)

Volume Fraction V_V = 0.588

Specific Surface area S_V = 33.35

B. 3(b)

Number of discs in reduced window = 233

Histogram of diameter with bin size = 0.01

Range of diameter = (0.00000mm, 0.1642417mm)

Empirical mean = 0.070635010mm

Empirical standard deviation = 0.037604244mm

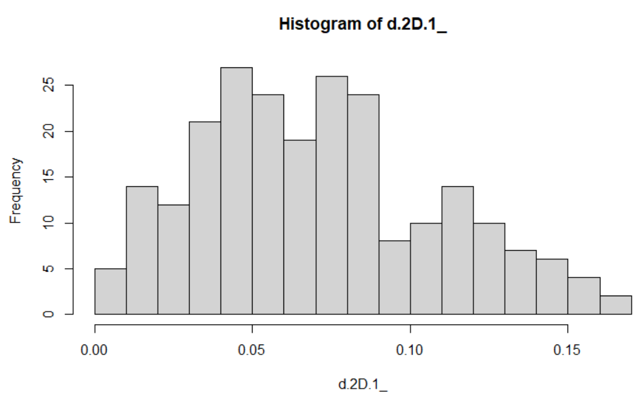


Figure 14 : Histogram of diameters in reduced window

C. 3(c)

Absolute frequency in 2d per unit square millimeter =
[2.784,7.796,6.683,11.695,15.0367,13.366,10.581,14.479,13.366,4.455,5.569,7.796,5.569,3.898,3.341,2.227,1.113]

Absolute frequency in 3d per unit cubic millimeter =[
98.751,244.715,29.0609,152.413,260.481,202.412,82.288,209.366,245.7077,18.621,31.255,99.860,68.627,42.926,43.100,32.148,19.386]

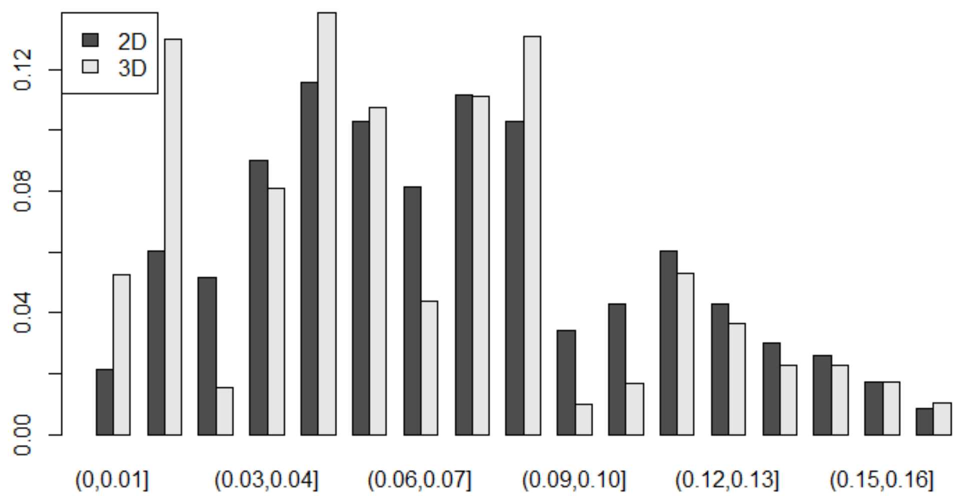


Figure 15 : Histogram of diameters in 2d and 3d

D. 3(d)

Estimate of intensity (λ_v) = **1881.127** balls/mm^3

Estimate mean ball diameter (μ_v) = **0.0689801** mm

V. Task 4

$\lambda_{Poi} = 4$

Empirical mean of area fraction = 0.0412615718

Empirical standard deviation of area fraction = 0.0019842920

Empirical mean of specific boundary length = 1.3682791928

Empirical standard deviation of specific boundary length = 0.0659243566

Empirical mean of Euler number = 3.5746457167

Empirical standard deviation of Euler number = 0.174460126026

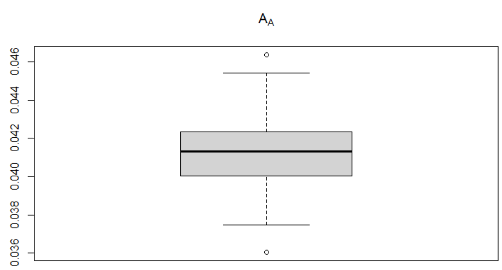


Figure a

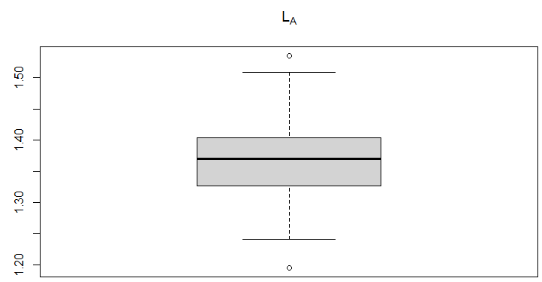


Figure b

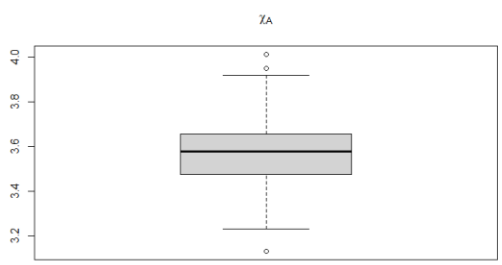


Figure c

Figure 16 : Box plots for Quermass density with $\lambda_{Poi} = 4$

$\lambda_{Poi} = 8$

Empirical mean of area fraction = 0.07635392148

Empirical standard deviation of area fraction = 0.0023778594

Empirical mean of specific boundary length = 2.52931941704

Empirical standard deviation of specific boundary length = 0.07839912853

Empirical mean of Euler number = 6.52404155907

Empirical standard deviation of Euler number = 0.20608436323

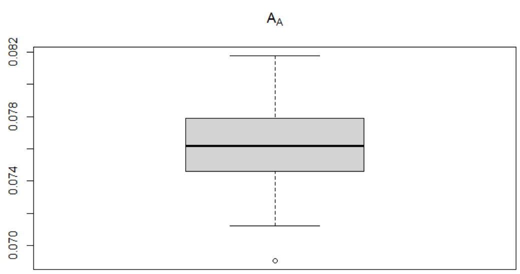


Figure d

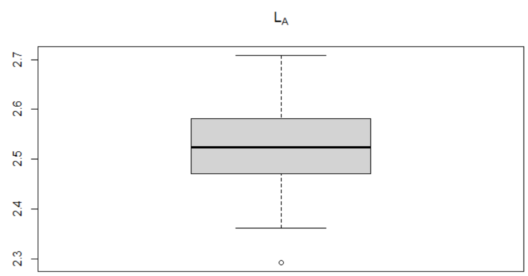


Figure e

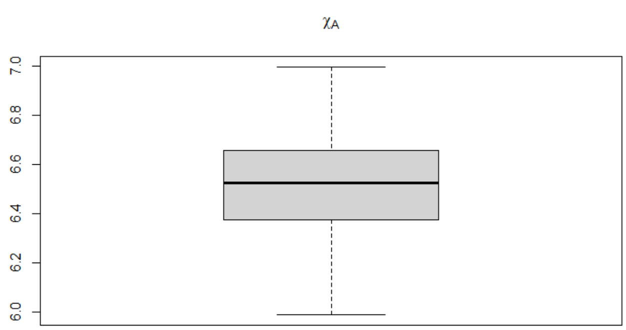


Figure f

Figure 17 : Box plot for Quermass Density with $\lambda_{Poi} = 8$

λ_{Poi} = 12

Empirical mean of area fraction = 0.1060048837

Empirical standard deviation of area fraction = 0.00275256278

Empirical mean of specific boundary length = 3.50992040409

Empirical standard deviation of specific boundary length = 0.09059992535

Empirical mean of Euler number = 8.9565792018

Empirical standard deviation of Euler number = 0.22683373405

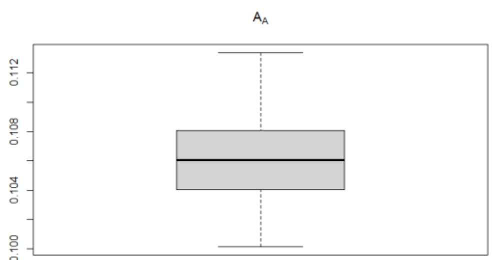


Figure g

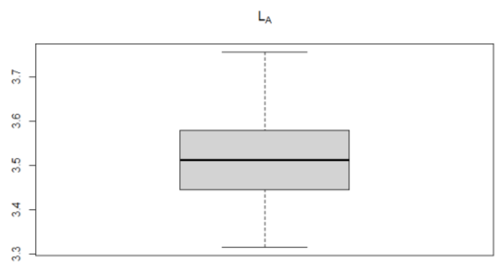


Figure h

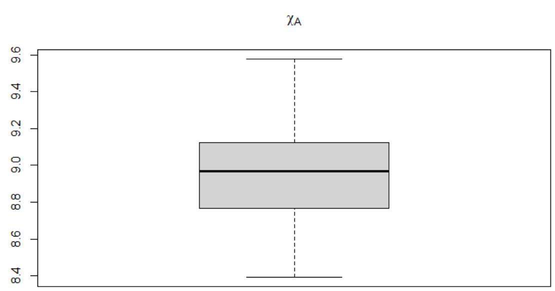


Figure i

Figure 18 : Box plots for Quermass Density with λ_{Poi} = 12