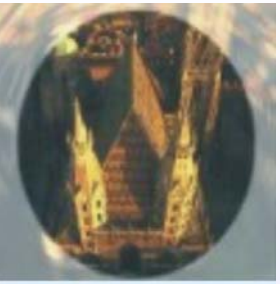

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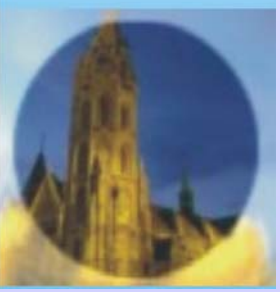
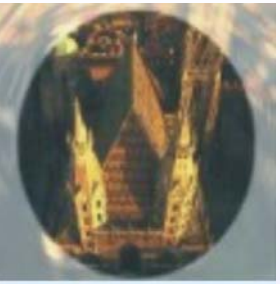


Some Aspects of NEA Classification

Florian Freistetter,13 May 2002



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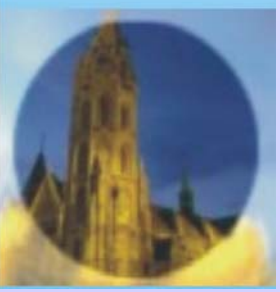
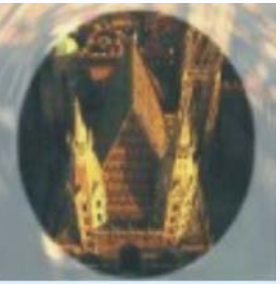


Why do we need to classify NEAs ?

- NEAs evolve on chaotic orbit
- therefore results for one individual object are „useless“
- one has to derive statistical values
- thus induces some sort of grouping

2 examples shall illustrate the problem →



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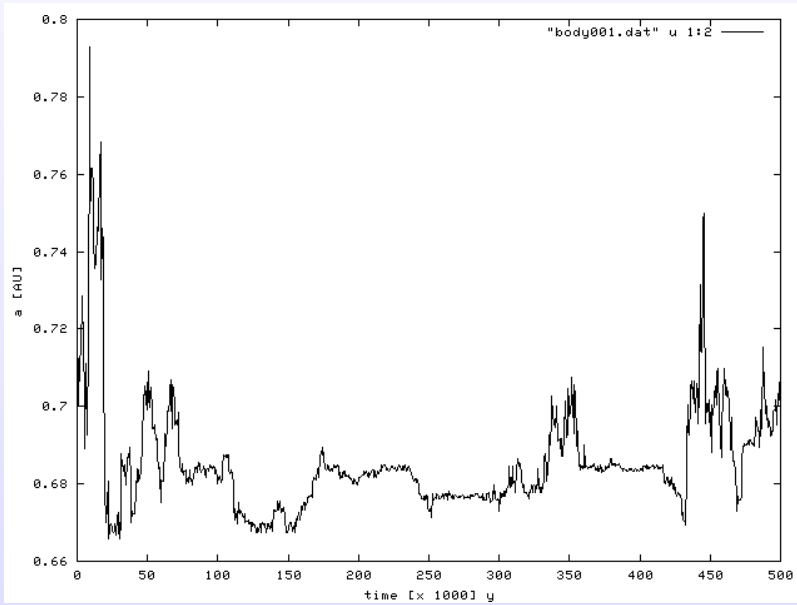
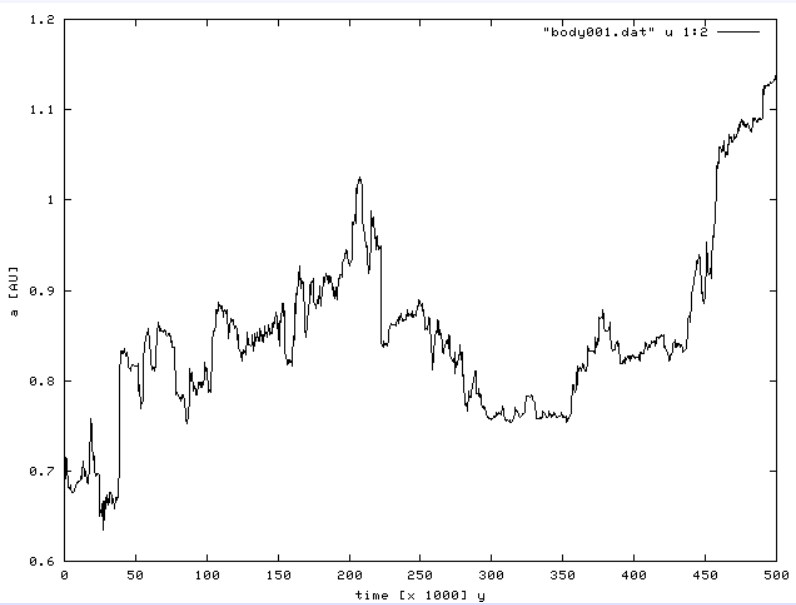
Example 1





Body 001 A

- a=0.7 AU, e=0.1, i=1°
- CP_{EARTH}=5,78E-08
- BCN= 0

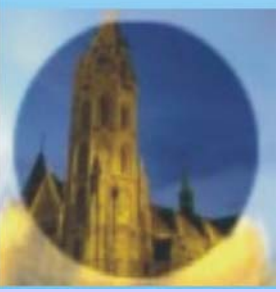
Pentium II Processor

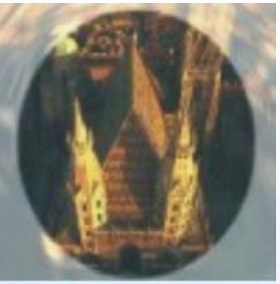
Body 001 B

- a=0.7 AU, e=0.1, i=1°
- CP_{EARTH}=6,98E-08
- BCN= 38

AMD 1800 Processor

different Integratorstepsize





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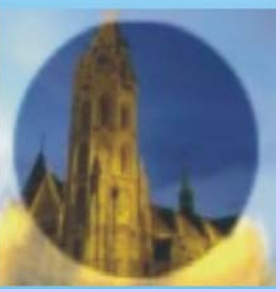
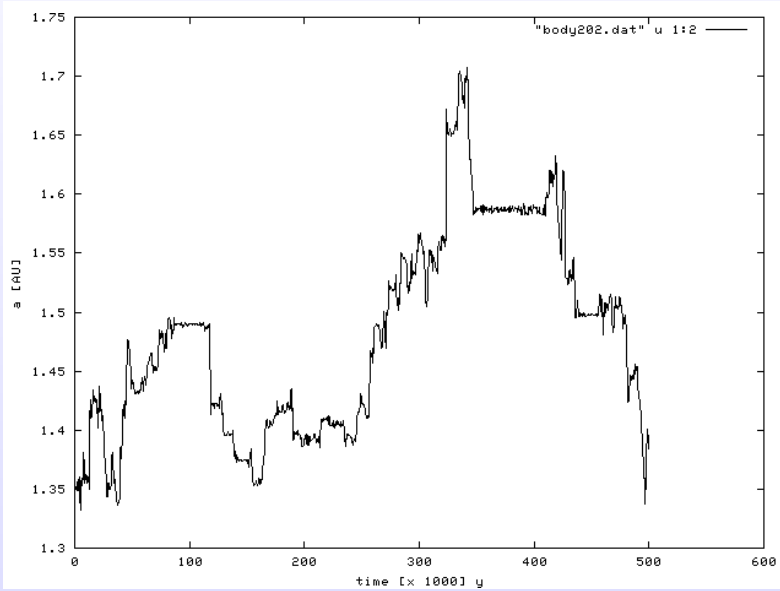
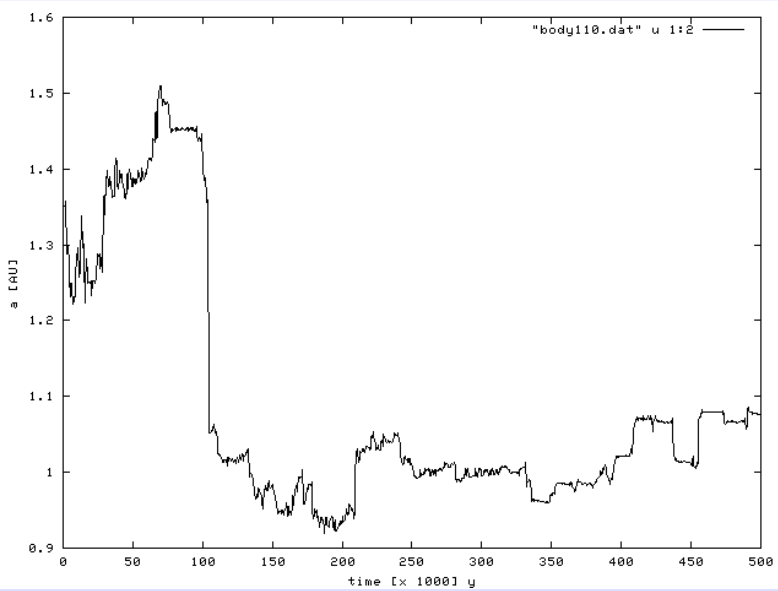


Example 2





Body 002 A

- a=1.35 AU, e=0.4, i=1°
- CP_{EARTH}=4,21E-08
- BCN= 0

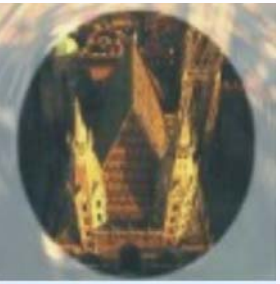
Pentium II Processor

Body 002 B

- a=1.35 AU, e=0.4, i=1°
- CP_{EARTH}=6,43E-08
- BCN= 58

AMD 1800 Processor

different Integratorstepsize



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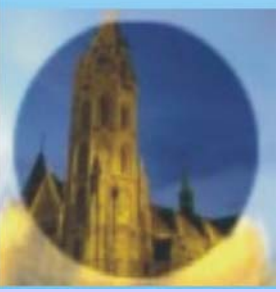


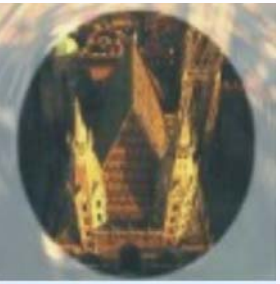
Grouped Asteroids

Model 1 (Pentium II)

- Aten (264 bodies) : CP_{EARTH}=7,85E-08
- Apollo (348 bodies) : CP_{EARTH}=5,26E-08
- Amor (54 bodies) : CP_{EARTH}=3,79E-09

Model 2 (AMD 1800)

- Aten (88 bodies) : CP_{EARTH}=7,52E-08
- Apollo (116 bodies) : CP_{EARTH}=5,20E-08
- Amor (18 bodies) : CP_{EARTH}=1,48E-09



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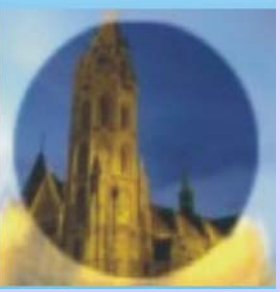
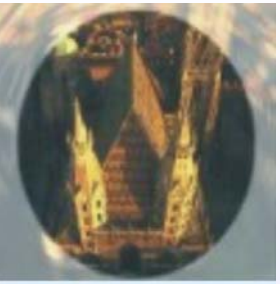


First „Rule“

If one deals with NEAs, one has to define groups.
The number of group members must be sufficient large !

First Problem

The number of group members is NOT constant !
NEAs suffer under MIXING !



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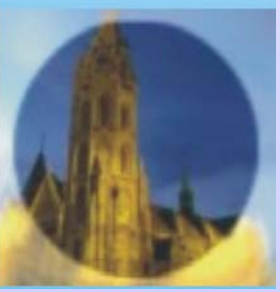


Mixing

Dvorak and Freistetter (2001) :

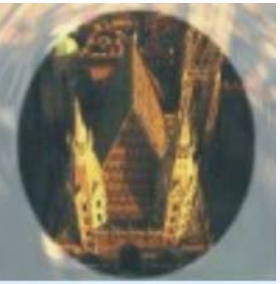
720 fictitous asteroids :

Mean Percentage of Membership			
Subaten	Aten	Apollo	Amor
53,74%	70,99%	83,00%	90,43%

Milani et al (1989) :

89 real asteroids :

Mean Percentage of Membership						
Geographos	Toro	Kozai	Alinda	Eros	Oljato	Comet
75,86%	22,90%	91,70%	55,05%	83,72%	65,13%	84,14%



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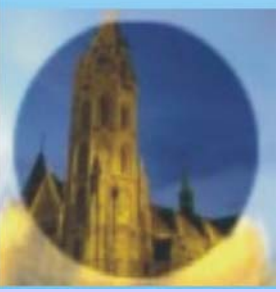
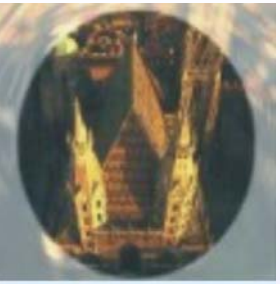


Problems due to mixing

Example : The APOLLO Group has a mean collision-probability with Earth of ~53 collisions in 10^9 years.
BUT : A „mean Apollo“ spends 11% of its time as an Aten, 83 % as an Apollo and 3% as an Amor !
(Dvorak and Freistetter, 2001)

Therefore : The grouping used for calculating statistical properties has to „sufficiently stable“ during integration time.



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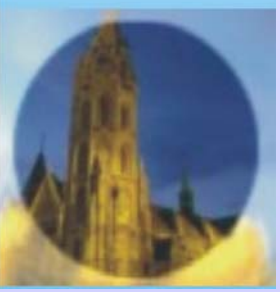
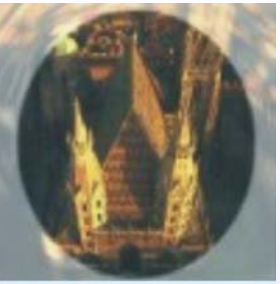


New ways of classification

- „Normal“ classifications are not stable enough.
- A new attempt to classify NEAs is based on the existing classes → „Meta Classification“
- Groups are also based on the dynamical properties → should be more stable then existing ones.



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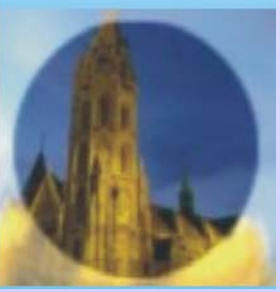
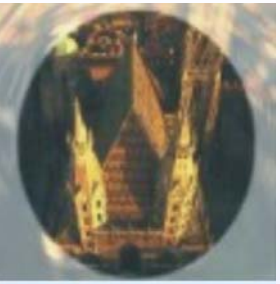


Border Crossing Numbers

Border Crossing Number (BCN) :=
Number of group changes in the
Aten/Apollo/Amor Classification

Distribution of BCNs was
checked for 720 asteroids
→



Border Crossing Numbers

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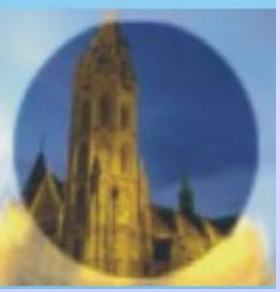

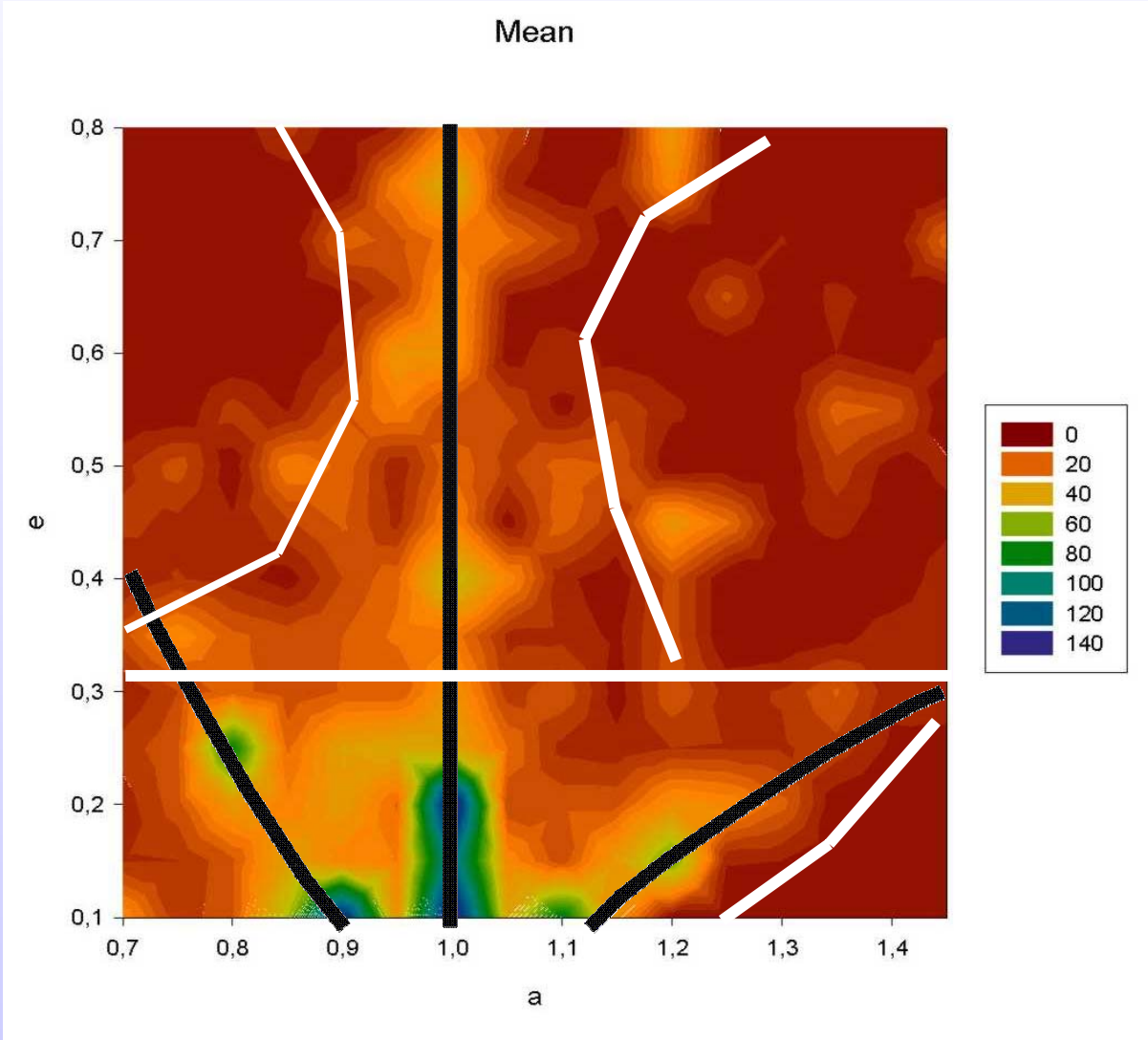

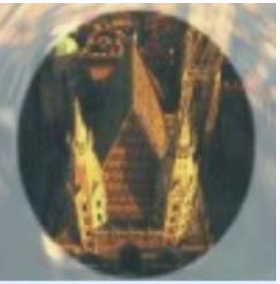

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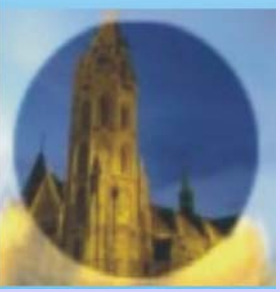
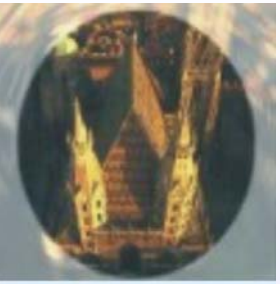


Fuzzy Classification

BCNs investigate the general properties of mixing. For a useful grouping some more details are needed :

- Direction of asteroidal flow in a-e plane
- Speed of asteroidal flow in a-e plane

This information leads to a „fuzzy classification“



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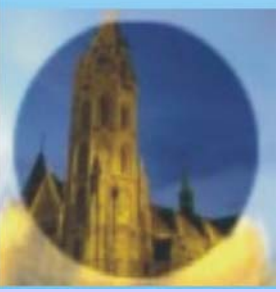
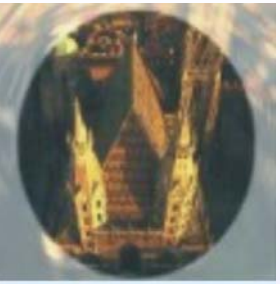


Fuzzy Classification

A fuzzy group needs a membership function that gives the grade of membership.
We want to establish a grouping, that gives, for a certain region in a-e space, that mean grade of membership to the classical Aten/Apollo/Amor classification.

This is done by calculation a „vector field“ →



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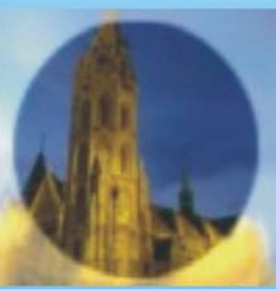
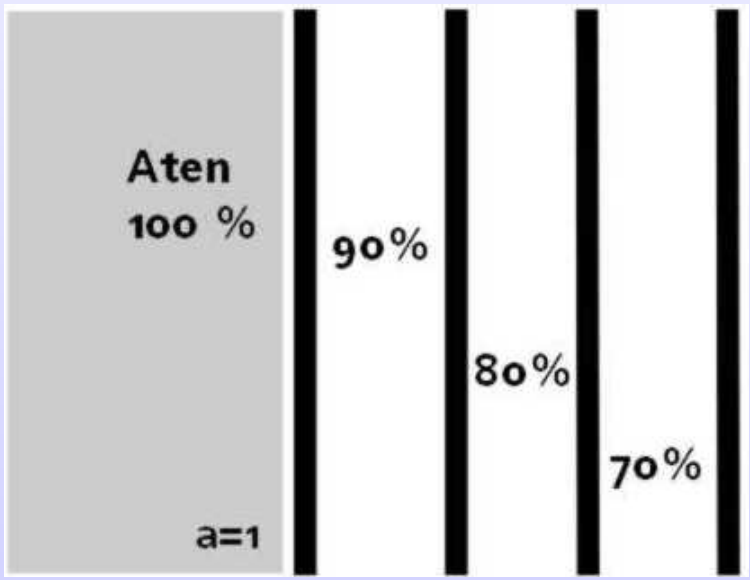


Fuzzy Classification

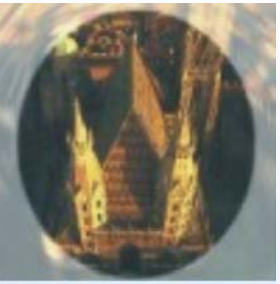
How to construct a membership function for NEAs:

1) make copies of the classical border and place them outside the original one :



Because the choice of this borders was „intuitive“ they have to be adjusted.

This is done by calculating the flow around the borders.



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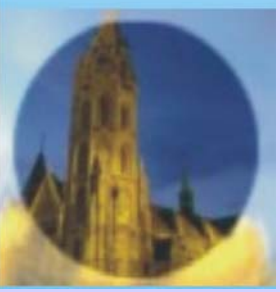
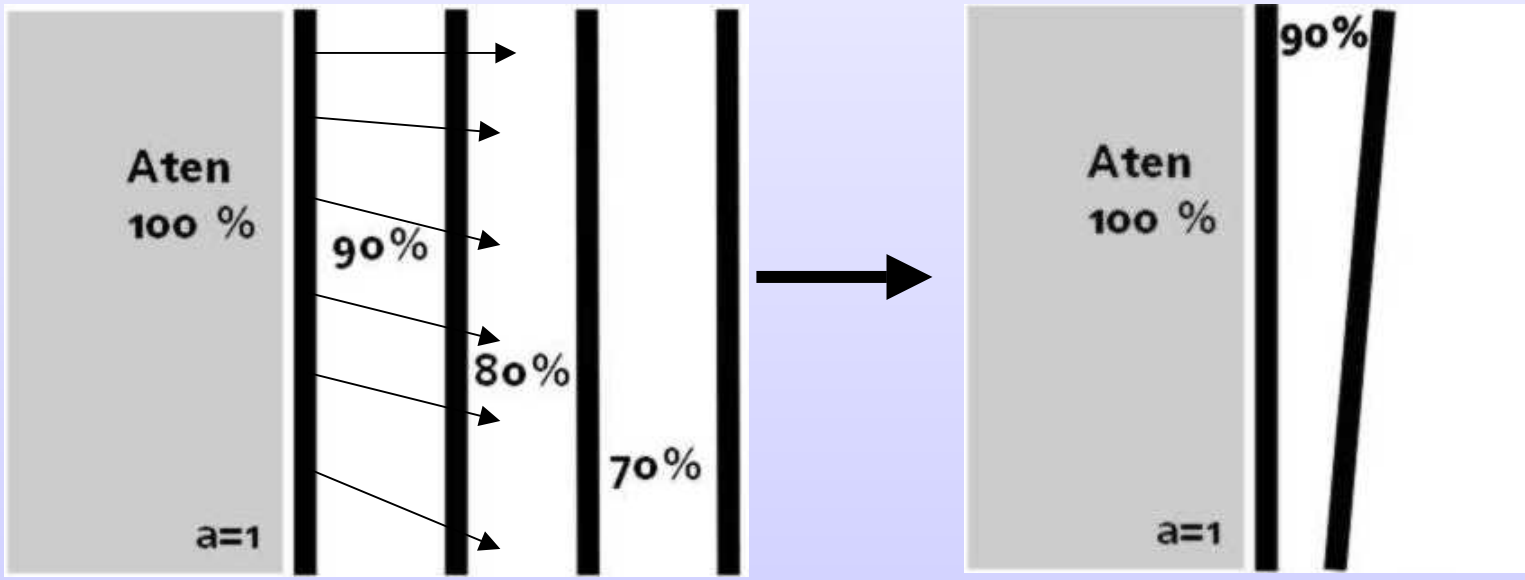
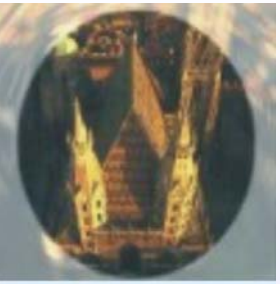


Fuzzy Classification

How to construct a membership function for NEAs:

2) calculate the direction and the velocity of the motion of an asteroid. This leads to a vector field that can be used to adjust the borders :





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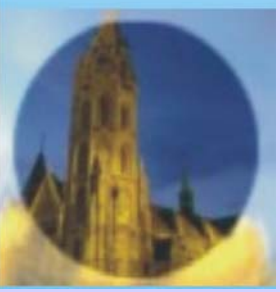
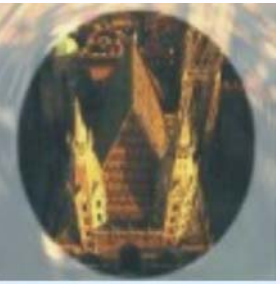


Refinement

The fuzzy grouping can be refined by several additional properties of NEAs :

- BCNs
- Collision Propabilities
- Effect of Resonances
- ….



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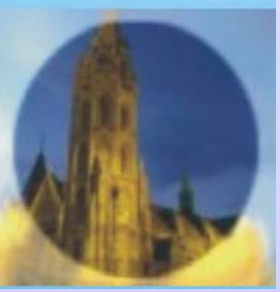

Conclusions

•Obtaining a stable grouping of NEAS for long time
•scales is very difficult

•One needs methods, that are based on the dynamics
•of the asteroids

•A lot of work is still needing to understand the mixing
•dynamics of planet crossing asteroids