Dynamics of the DOT/LaPalma G-band bright points

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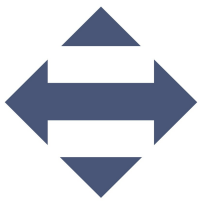
3rd International workshop on small scale solar and stellar magnetic fields
April 3 - 5, 2013
Bairish Kölldorf, Austria



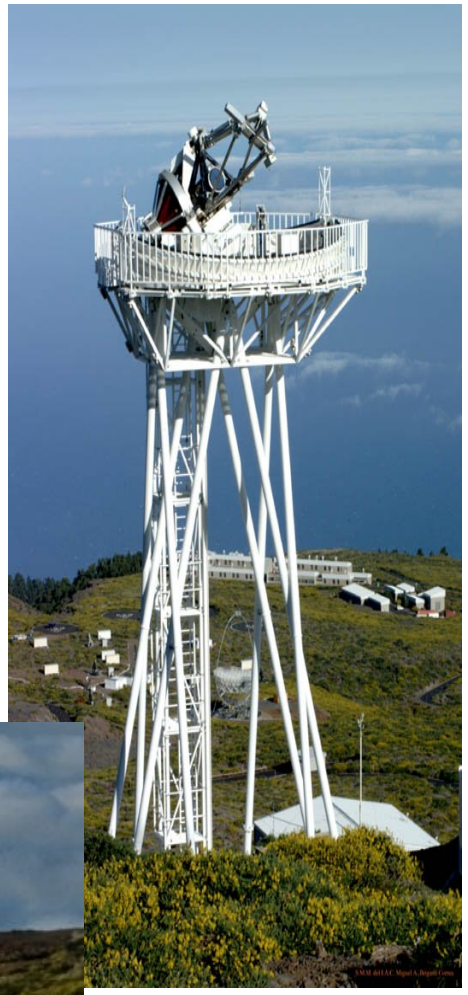
SLOVAK RESEARCH AND DEVELOPMENT AGENCY

Introduction – G-band bright points

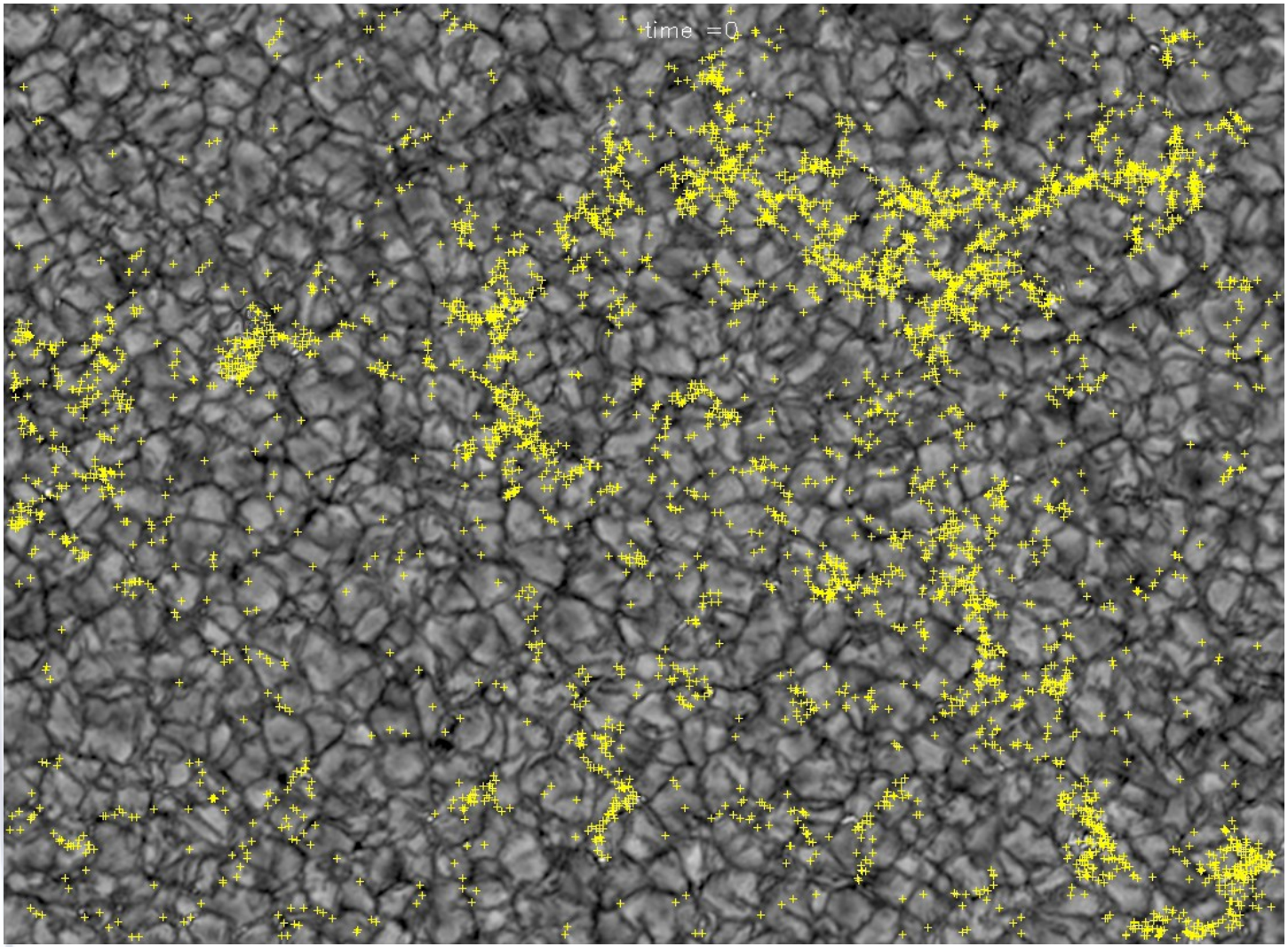
- are revealed if the sun is imagined in the G-band (spectral range at 430 nm dominated by electronic transitions of the CH-molecule) at a sufficiently high resolution as isolated brightenings
- are interpreted as small-scale magnetic field concentrations that are embedded in the convective flow field of the solar photosphere
- as manifestations of small-scale magnetic fields they become important for the understanding of the coronal heating process and the variability of the solar irradiance

Data

- speckle reconstructed images of the quiet solar photosphere in G-band (430 nm)
- Dutch Open Telescope (DOT) 19.10. 2005 (09:55 - 11:05 UT, 142 images, cadence 30s)
- size: 1112 pixel $\times$ 818 pixel
- FOV: 79 $\times$ 58 arcsec
- sampling: 0.071 arcsec/pixels



Data



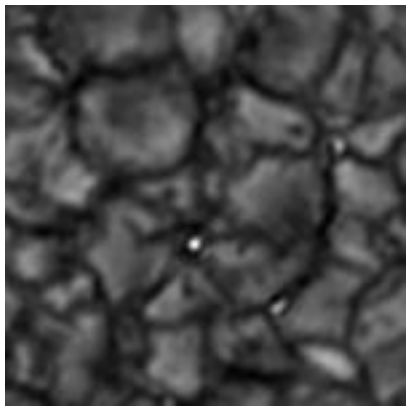
a sample G-band image of the quiet solar photosphere (FOV: 78 by 59 arcsec) with the indicated locations of the tracked GBPs

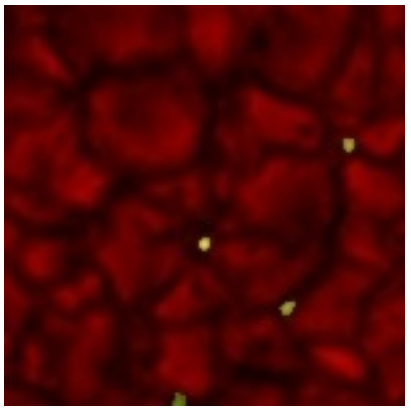
Identification and tracking of GBPs

- GBPs were identified and tracked on G-band images using the algorithm developed by Utz et al. *(A&A 498, 289-293, 2009)*
- 26238 GBP identifications of 4017 tracked GBPs on all 142 images of the data set
- statistical properties of the tracked GBPs:

  average radius (244.9 ± 37.62 km)
  average lifetime (3.0 ± 2.72 min)
  median of velocity (1.3 km/s)

example of the G-band bright point identification using the Utz's algorithm





Dynamics of GBPs

Aim: to present a compact study of various traditional and new parameters describing dynamics of tracked GBPs

Studied parameters:

- effective velocity ***v***
- change in effective velocity ***dv/dt***
- change in direction angle ***Δφ***
- centrifugal acceleration ***vdφ/dt***
- rate of motion ***d/r***
- time lag between recurrence

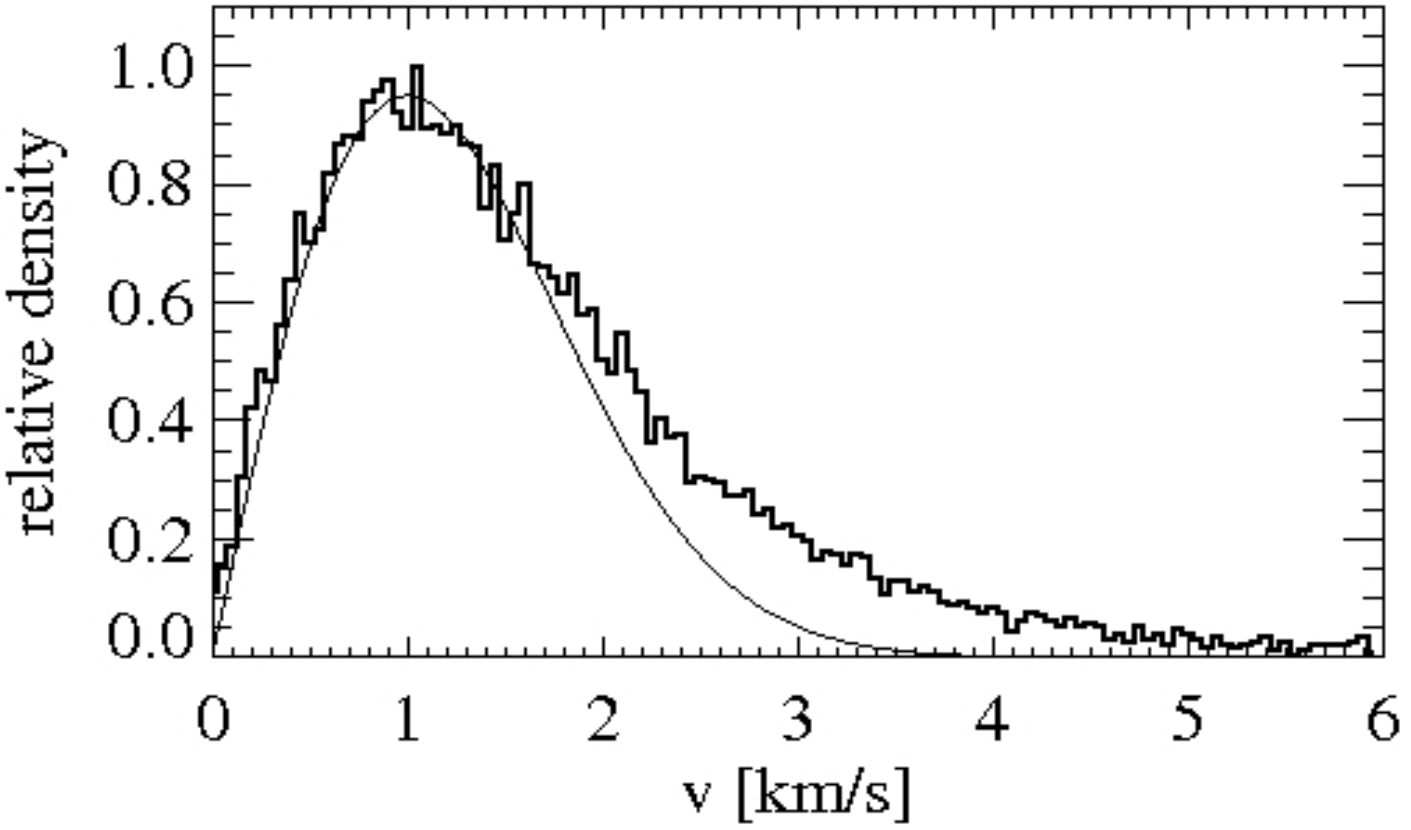
Effective velocity

- range: 0 - 6 km/s
- median value: 1.384 km/s
- most probable value: 0.9 km/s
- only 10% are higher than 3 km/s

$$v = \sqrt{v_x^2 + v_y^2}$$

$$f(v, \sigma) = \frac{v}{\sigma^2} \exp\left(\frac{-v^2}{2\sigma^2}\right)$$

- sample Rayleigh distribution (σ=1)
- deviation → increased numerosity of velocities in the range: 2 - 4 km/s

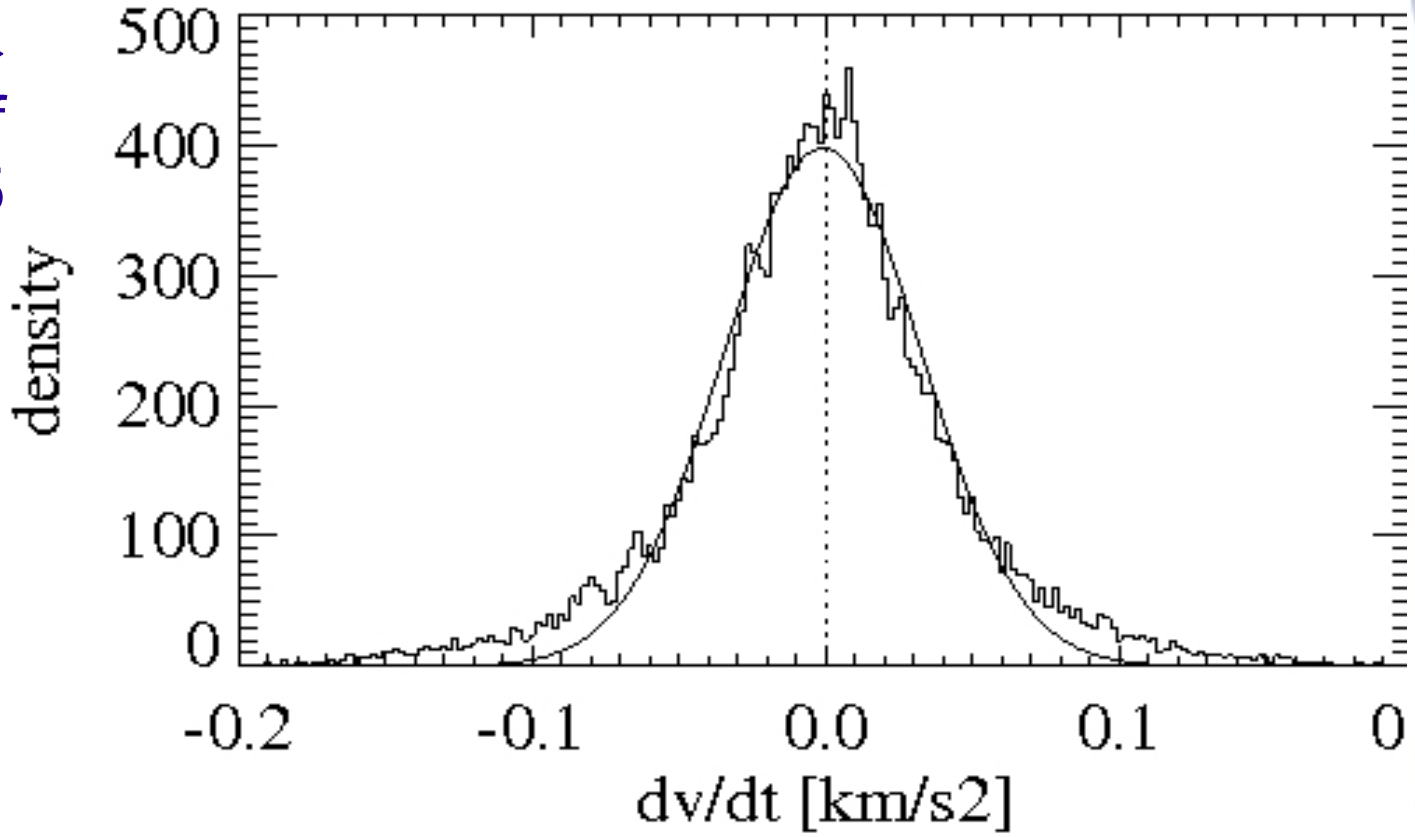


Change in effective velocity

- positive (acceleration) and negative (deceleration) values in range: (-0.2) – (0.2) km/s²
- 77.8% values in range: (-0.05) – (0.05) km/s²

$a = dv/dt$

- 0.05 km/s² → increase of velocity by 1.5 km/s after 30 s
- Gaussian fit: FWHM = 0.074 km/s²

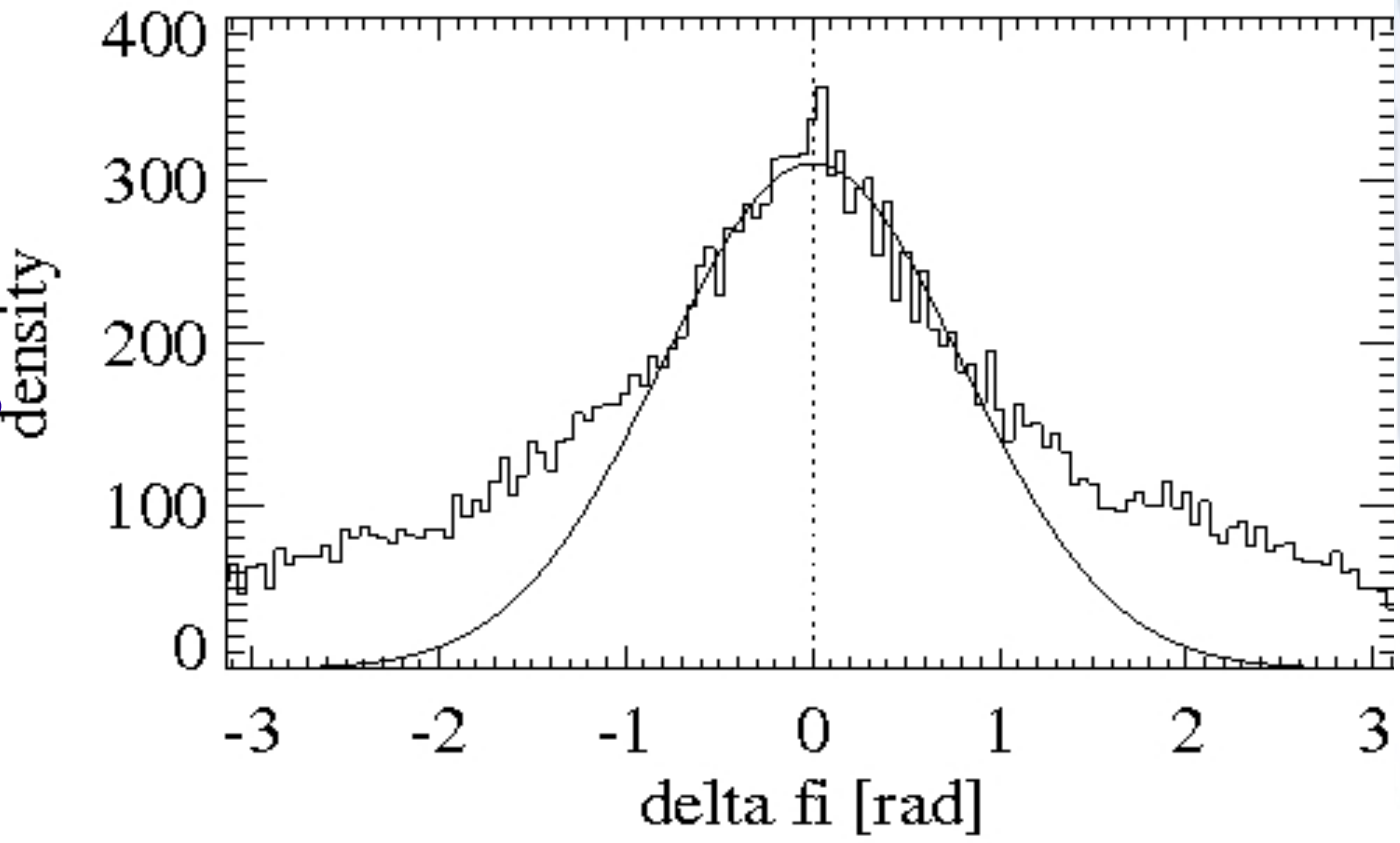


Change in direction angle

- change in direction of motion of GBPs between two successive time steps (30s)
- each possible value has nonzero probability
- not Gaussian as a whole
- 54.5% values (from -1 up to 1 rad) Gaussian fit: FWHM = 1.93 km/s²
- ratio of retaining direction to changing essentially: 3.08

$$\Delta\varphi = \varphi_2(t_2) - \varphi_1(t_1)$$

$$t_1,\ t_2\ (\ t_2 = t_1 + 30s)$$



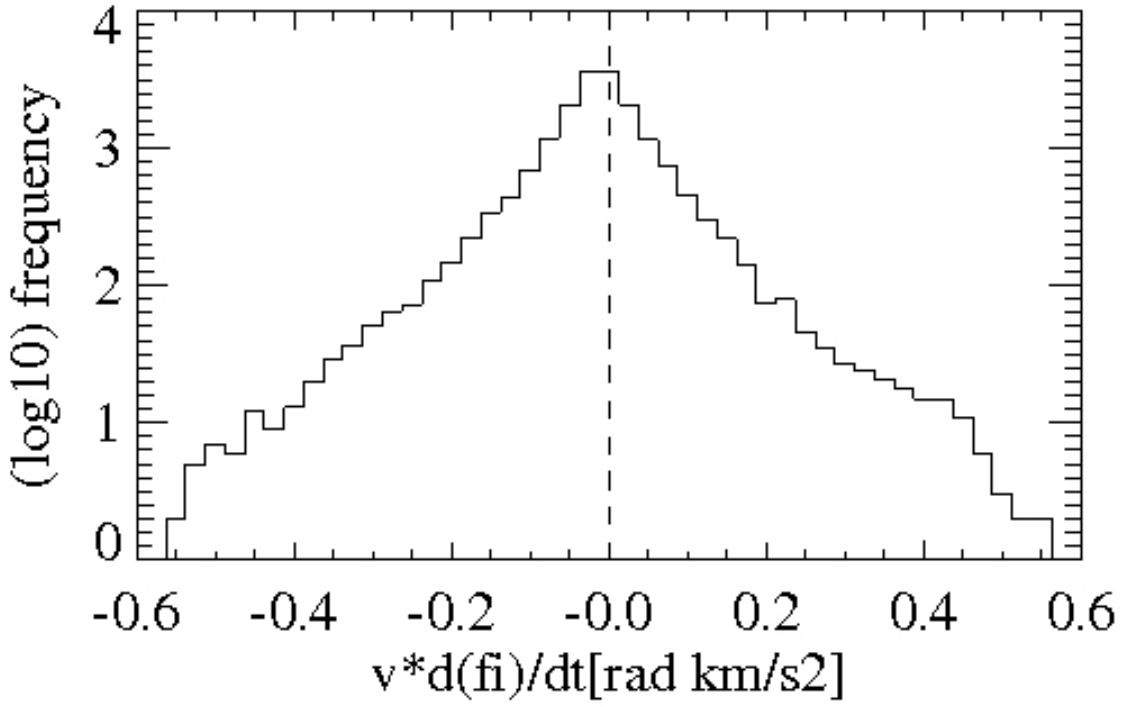
Centrifugal acceleration

- is a relevant quantity when considering the generation of waves in magnetic flux tubes

$$a = v\, d\varphi/dt$$

- exponential distribution → logarithmic scale

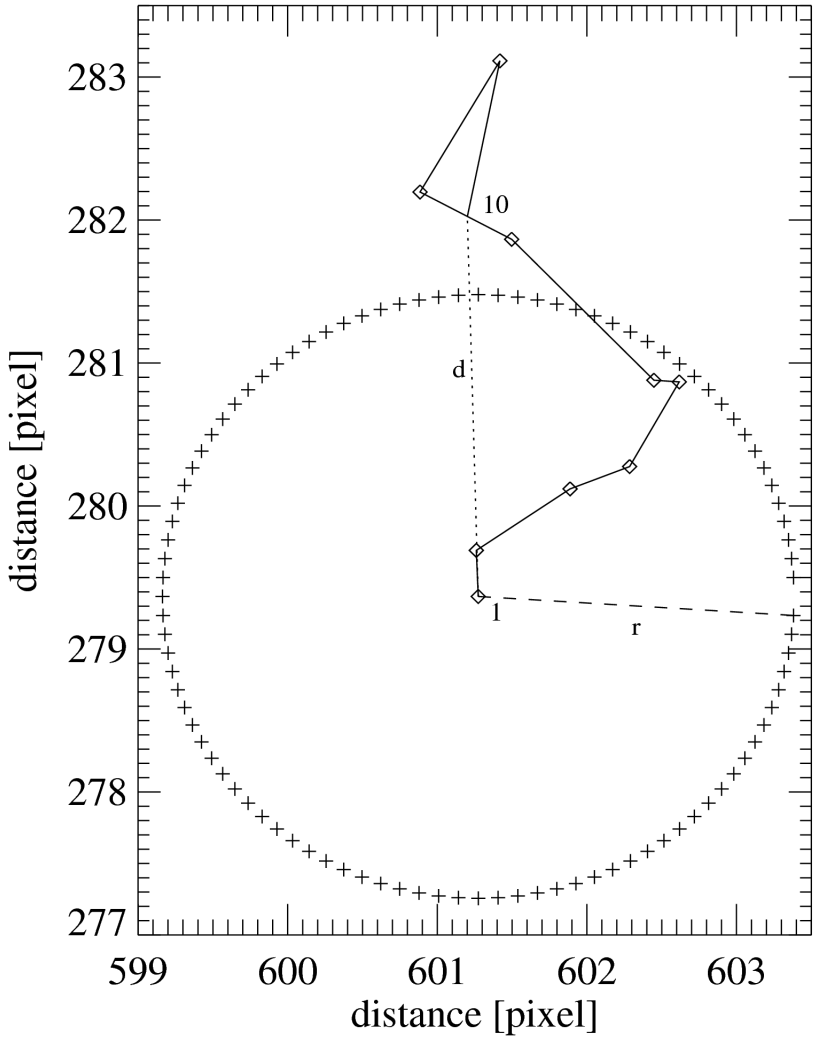
- slightly asymmetric with a pronounced excess around ~ 0.4 rad km/s²



Rate of motion (1)

- location of GBP = location of its barycenter of brightness
- the observed motion of GBPs is minimal – distances made during existence are mostly up to ~1 arcsec
- mean area of a GBP: ~2.016 arcsec²
- ***m*** indicates if the GBP at the end of its existence left the circle given by the size of the GBP at its fist identification
- ***d*** is the distance between the first and the last barycenter
- ***r*** is the radius of the initial circle of existence)

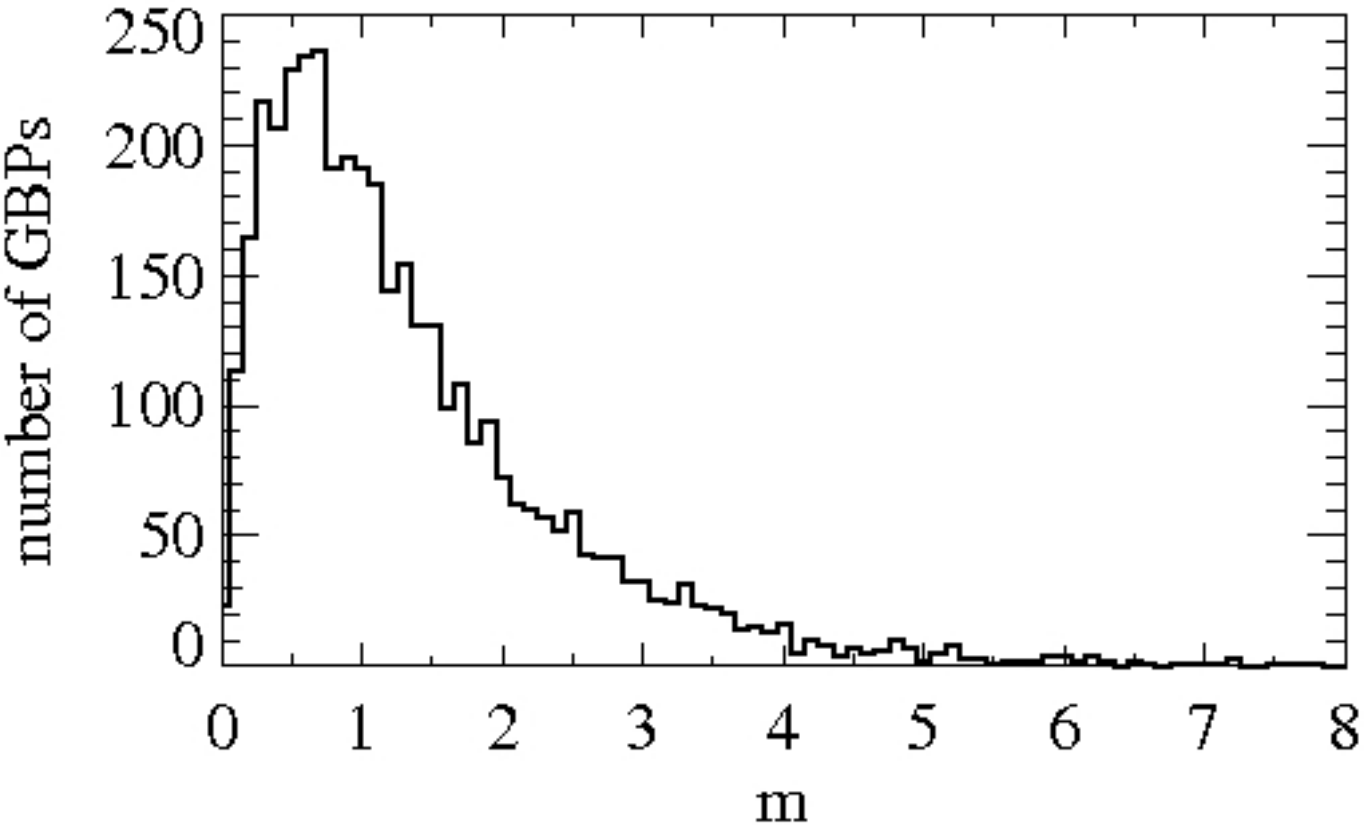
$$m = \frac{d}{r}$$



Rate of motion (2)

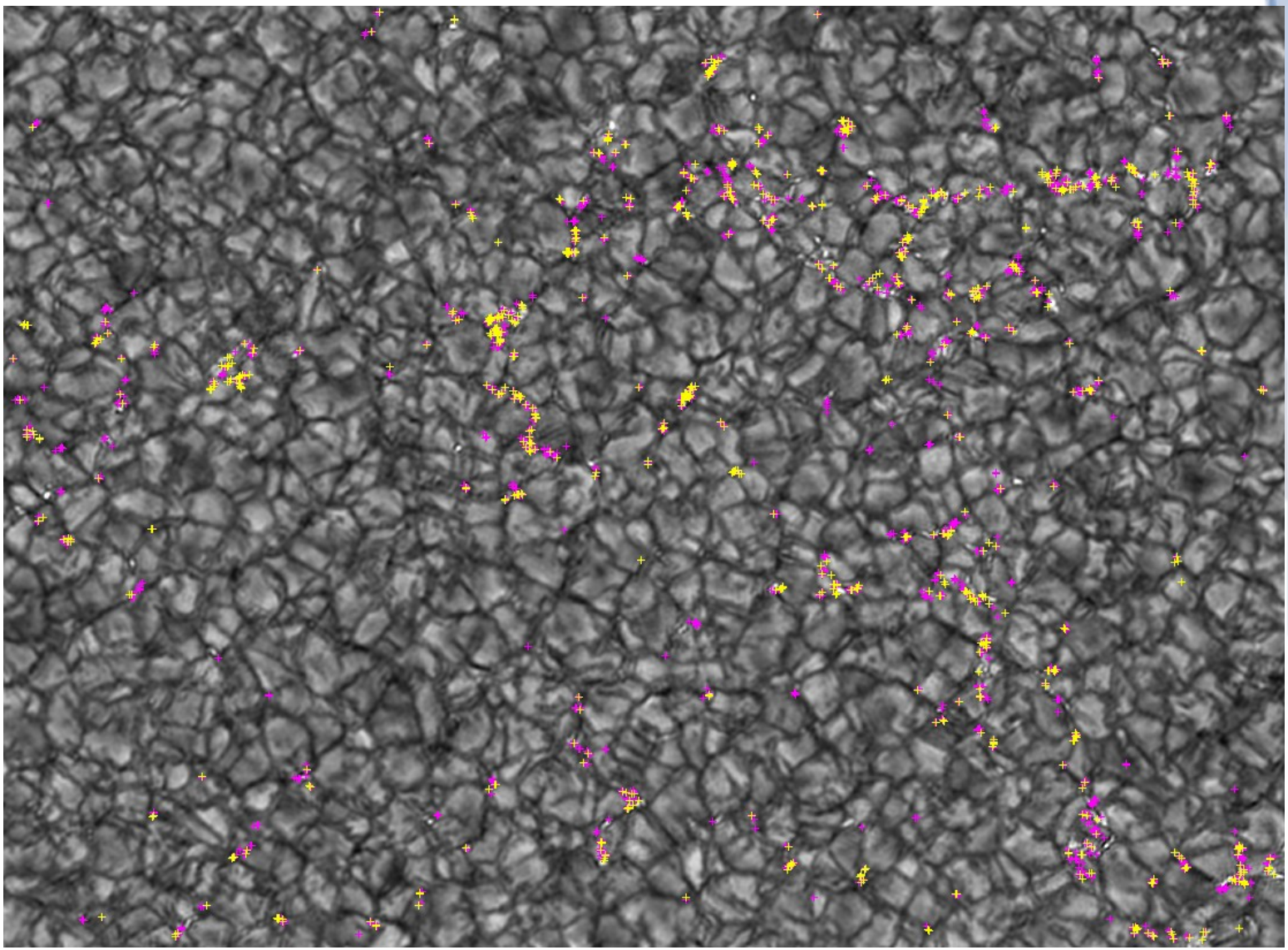
- ~45% GBPs: m<1 → within the circle of the first identification
- ~55% GBPs: m>1 → outside of the circle of the first identification

- ~18.5% have 2<m<4 → significant movement, which cannot be accounted to the method of definition of the location of GBPs



Rate of motion (3)

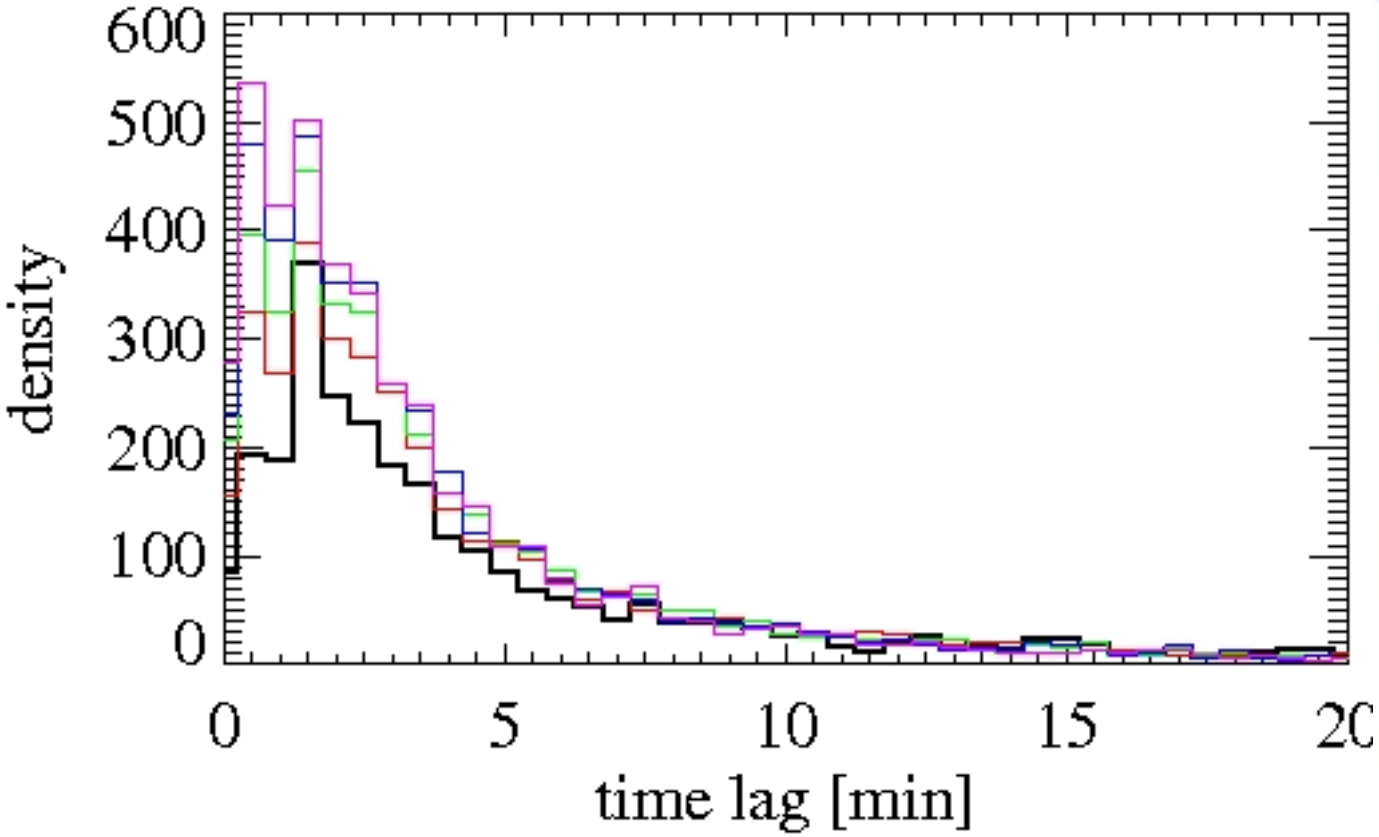
a sample G-band image of the quiet solar photosphere (FOV: 78 by 59 arcsec) with the indicated locations of the tracked GBPs with **m<1** and with **m>2**



Time lag between recurrence of GBPs

- the frequency of recurrence of different GBPs on the same locations - areas of a given size
- studied areas: **0.35**, **0.49**, **0.63**, **0.78** and **0.92** arcsec

- small time lags (up to ~4 min) → higher densities
- most numerous: ~2-3 min
- time lags longer than ~10 min are less frequent



Summary

- effective velocity: most probable value: ~0.9 km/s; deviation from the Rayleigh function ($\sigma = 1.0$) in the range ~2-4 km/s
- change in effective velocity: Gaussian shape (FWHM = 0.074 km/s^2)
- change in direction angle: non-Gaussian shape → the central peak (54.5% of values) has a Gaussian shape (FWHM = 1.93 rad)
- centrifugal acceleration - exponential distribution
- rate of motion: ~45% of tracked GBPs → displacement is smaller than their initial size; locations of GBPs with m<1 and m>2 does not significantly differ
- time lag of recurrence of GBPs: most numerous are lasting ~2-3 min and lags up to ~4 min are more numerous than longer lags

Conclusion

- our results for effective velocities, change in direction angle and centrifugal acceleration are acknowledging the results of previous authors
- we defined two new parameters: to help to estimate the real displacement of GBPs during their existence (rate of motion) and the frequency of their recurrence on the same locations (time lag between recurrence of GBPs)
- the observed movement of GBPs is within a small area along the intergranular lanes
- there is no difference in locations of stable and more vigorously moving GBPs
- numerous relatively short time lags indicate that GBPs tend to vanish and reoccur on their locations

Thank you for your attention!