

Variability time scales from long term monitoring

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Overview

- ◆ Introduction
- ◆ Data and Methods
- ◆ Observational time scales
- ◆ Considerations
- ◆ Intrinsic time scales
- ◆ Future



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Introduction

- ◆ Variability studies of a large sample of sources
 - Time scale analysis
 - ◆ Differences between classes
 - ◆ Differences between frequencies
 - Comparing different methods
 - Comparing results with earlier paper by Lainela & Valtaoja (1993, ApJ, 416, 485)



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The Data

- ◆ 80 sources from the Metsähovi monitoring sample
 - HPQ, LPQ and BLO sources and Radio Galaxies
- ◆ Data at 4.8, 8, 14.5, 22, 37, 90 and 230 GHz
 - data from Metsähovi at 22, 37 and 90 GHz
 - ◆ some have been monitored for over 25 years
 - 4.8, 8 and 14.5 GHz from the UMRAO
 - 90 and 230 GHz monitoring data from the SEST
 - 90 and 230GHz published data from IRAM



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Methods

- ◆ The Structure Function
 - Smaller variations and the structure of the flux curve
- ◆ Discrete correlation function
 - Autocorrelation
- ◆ Lomb-Scargle periodogram
 - Peak-to-peak time scales



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Average time scales

Frequency	SF	DCF	Periodogram
4.8 GHz	5.2*	6.6 (5.1**)	8.7 (7.5)
8 GHz	5.6	9.4 (7.1)	9.7 (9.0)
14.5 GHz	4.3	8.1 (6.6)	8.5 (8.0)
22 GHz	4.1	5.6 (4.4)	6.6 (5.5)
37 GHz	2.6	5.1 (4.1)	7.0 (6.2)
90 GHz	2.0	3.8 (3.5)	4.9 (3.7)

* All time scales are in years

** For DCF and Periodogram analysis also the time scale with no lower limit estimates (T/2) are shown

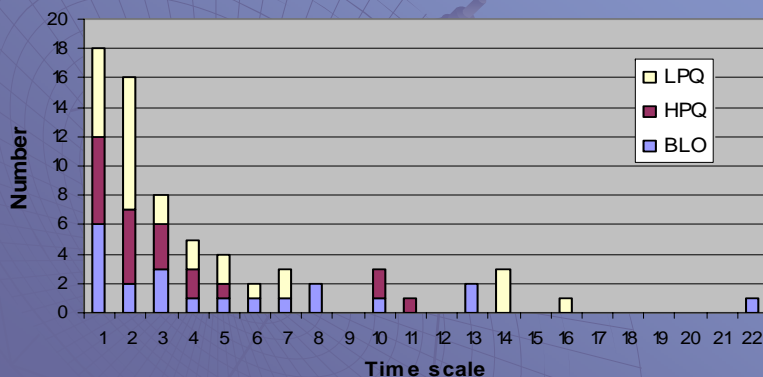


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Distributions of SF time scales

Distribution of time scales at 22 GHz

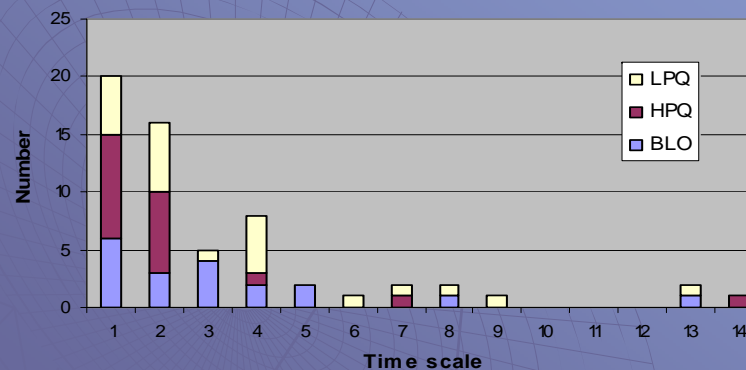


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Distributions of SF time scales

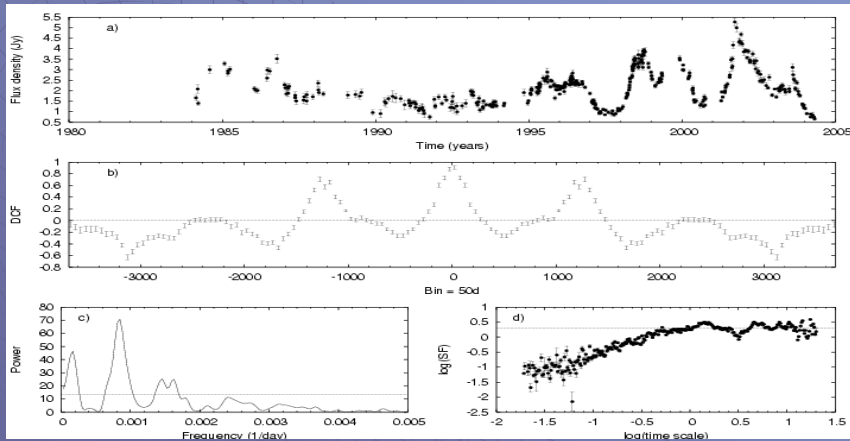
Distribution of time scales at 37 GHz



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Example 1156+295 (4C 29.45)



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Example 1156+295 (4C 29.45)

- ◆ Time scales from DCF and Periodogram are very similar
 - 3.29 years from periodogram
 - 3.49 years from DCF
- ◆ Shorter time scale of 1.2 years from the SF
 - Much shorter compared to time scale of 6.8 years from Lainela & Valtaoja 1993



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Comparison of SF time scales with earlier analysis

- ◆ 42 sources
- ◆ L&V found significant differences between classes
 - LPQs and HPQs differed from each other
- ◆ Averages have changed
 - 22 GHz: 2.6 years \rightarrow 4.8 years
 - 37 GHz: 2.3 years \rightarrow 2.6 years
- ◆ Number of lower limit estimates has decreased from 32 to 10

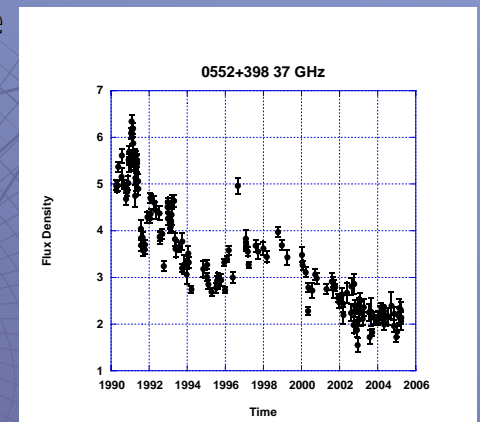


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Considerations

- ◆ Harmonic T/n time scales from periodogram analysis
 - Real time scales shifted in time
- ◆ Baseline effects
- ◆ Gaps in the data
- ◆ Faint sources



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Summary of the Results

- ◆ Peak-to-peak flare time scales are long with average closer to 7 years
- ◆ Short term variations can be also seen
- ◆ More than one method is needed to reveal all of them



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Summary of the results

- ◆ Higher frequencies ≥ 22 differed from lower ones significantly for all methods.
- ◆ Set of Kruskal-Wallis analysis for all methods did not reveal any significant differences between classes for most of the frequencies



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Averages after z-correction

Freq	BLO	BLO intrinsic	HPQ	HPQ intrinsic	LPQ	LPQ intrinsic
4.8	9.58	7.08	7.34	4.02	9.15	4.49
8	9.38	6.84	9.52	5.07	9.76	4.94
14.5	7.83	6.13	8.59	4.73	8.87	4.26
22	6.50	5.02	6.39	3.36	6.87	3.18
37	7.03	5.50	6.74	3.57	7.28	3.55
90	4.90	2.89	5.10	2.94	4.58	2.62



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Differences between the classes

- ◆ Intrinsic time scales from periodogram analysis revealed significant difference between BLOs and quasars.
- ◆ In SF and DCF analyses none of the classes differed clearly from others.



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In Preparation

- ◆ Correction for Doppler-boosting
 - Doppler boosting factors from Lähteenmäki et al. 1999 (ApJ, 521, 493)
 - Correlation between corrected luminosity and time scales



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Future

- ◆ Results will be published in Hovatta et al. later this year
- ◆ Nieppola et al. with more detailed analysis of BL Lacertae objects
 - Flares and time scales
- ◆ Wavelet analysis for the same sample
- ◆ Flare analysis for all well monitored flares



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