





Squeezing in GEO600

Henning Vahlbruch, Hartmut Grote, Alexander Khalaidovski, Nico Lastzka, Christian Gräf, Karsten Danzmann and Roman Schnabel

AEI Hannover

Henning Vahlbruch

Squeezing in GEO600



AEI squeezed light source & coherent control scheme

Squeezer implementation at GEO600

- optical
- different control schemes

Sensitivity improvement ... present & future

Henning Vahlbruch

Squeezing in GEO600

The GEO600-Squeezer



• Custom made breadboard: 1,35m x 1,15m, 120kg

Henning Vahlbruch

Squeezing in GEO600

GEO600 Squeezer - optical scheme





Phase noise vs. strong squeezing



Henning Vahlbruch

Squeezing in GEO600

GEO600 Squeezer - coherent control



GEO600 Squeezer - coherent control







GEO600 squeezed light source cavity



- PPKTP as non-linear medium
- Linear cavity design
- High mechanical stability
- sealed air gap
- low intra cavity loss = high squeezing escape efficiency



Squeezing in GEO600

Lots of squeezing!

with only some mW pump power



II % optical
loss on the
squeezing
board,
including
diagnostic
homodyne
detector

Henning Vahlbruch

Squeezing in GEO600



 Diagnostic homodyne detector introduces extra loss of 4% which can be substracted for application in GW-detector



Local squeezing after one year at GEO

CDS system remote controls analog electronics
Duty cycle >99%



Transport of the GEO600-Squeezer

Henning Vahlbruch

Squeezing in GEO600

Transport of the GEO600-Squeezer

Henning Vahlbruch

Squeezing in GEO600

Transport of the GEO600-Squeezer

 Not a single damage during transport

• started 9am,

wiskey at 3pm

• 2 days for

realignment

after 2 weeks local
 squeezing measured
 again

Henning Vahlbruch

Squeezing in GEO600

Squeezing alignment with a bright beam

Henning Vahlbruch

Squeezing in GEO600

Laser frequency synchronization

Henning Vahlbruch

Squeezing in GEO600

First "squeezing" at GEO

Henning Vahlbruch

Squeezing in GEO600

Longitudinal squeezing phase lock

Henning Vahlbruch

Squeezing in GEO600

Henning Vahlbruch

Squeezing GEO600

Optical loss for the squeezing

Henning Vahlbruch

Squeezing in GEO600

Loss chart

Henning Vahlbruch

Squeezing in GEO600

Squeezing with the new SRM

Spectrum plot using Kaiser window

Henning Vahlbruch

Squeezing in GEO600

Phase lock: Different sensor & actuator

Henning Vahlbruch

Squeezing in GEO600

Squeezing over the weekend

Spectrum plot using Kaiser window

Henning Vahlbruch

Squeezing in GEO600

Full power & squeezing

Henning Vahlbruch

Squeezing in GEO600

What's next

 Improvement of phase lock DCstability or noise locking scheme for very low frequencies

 Automatic alignment. Almost unexplored yet. Perhaps OMC refl. signals useful as well?

• More squeezing:

- Reduce OMC losses
- Lower loss setup between squeezer and GEO
- Increase of longitudinal phase locking bandwidth

What we have learned so far

 The GEO600 squeezed light source is working very well

 I0dB squeezing available
 long term stable

Gained experience how to implement squeezing into the interferometer world.

- optically
- control scheme
- For higher detected(!) squeezing levels lower optical loss on the interferometer side is required.
- Still several lessons left to learn...

Squeezing in GEO600