bKAGRA suspension ideas

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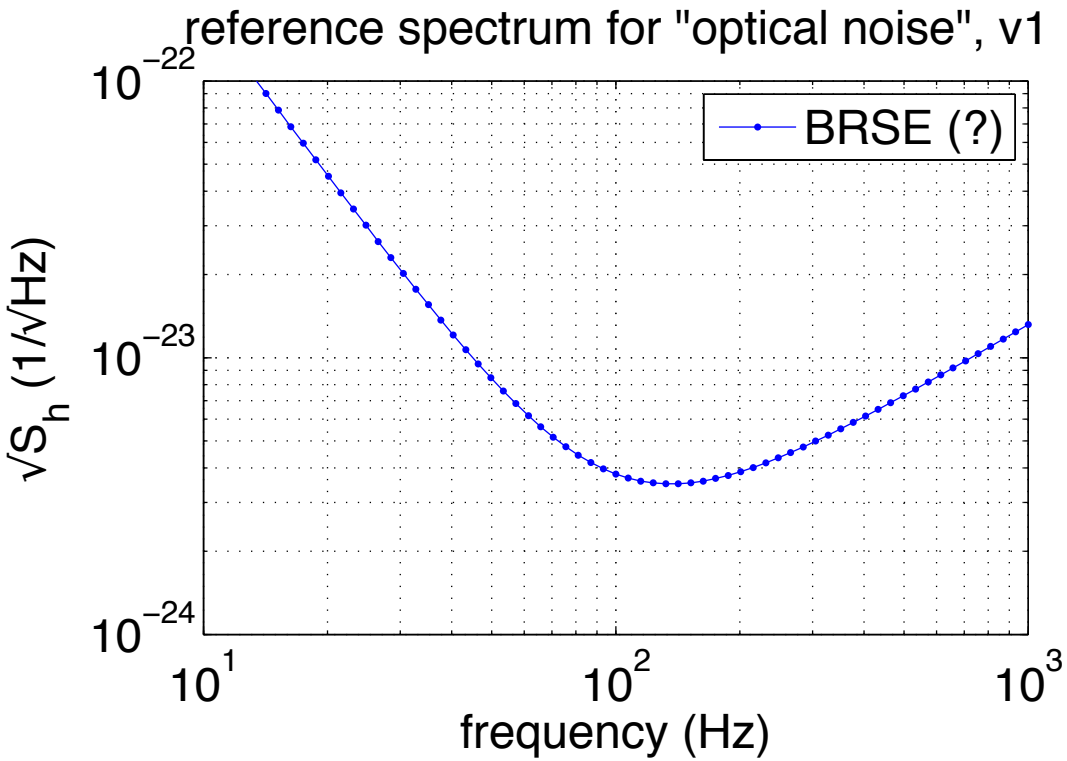
Proposed design requirements for bKAGRA suspension

1. All suspension noises lower, by the factor F (?) than reference “optical noise”.



Proposed design requirements for bKAGRA suspension

2. Must have ? maximum force actuation, and ? marionette stability,

   for 0 < frequency < 8 kHz
3. Must have ? sensor sensitivity, relative to reaction mass.
4. Must extract 1 W (?) of heat.

Separate the suspension functions

1. For **support against gravity**:use metal wires, such as Cu:Be, which is strong, NOT fragile, and has very high Q at low T
2. For **heat link**, use single crystal sapphire ribbon, NOT supporting the weight. (No tension -> less suspension noise.)

- Separation of functions makes it easier to design the critical attachment interfaces.
- Critical design problem will be to accommodate the differential contraction of different materials.
- Metal support wires are robust
- Crystal ribbons under tension are probably prone to brittle fracture.

Q vs Temp for one alloy

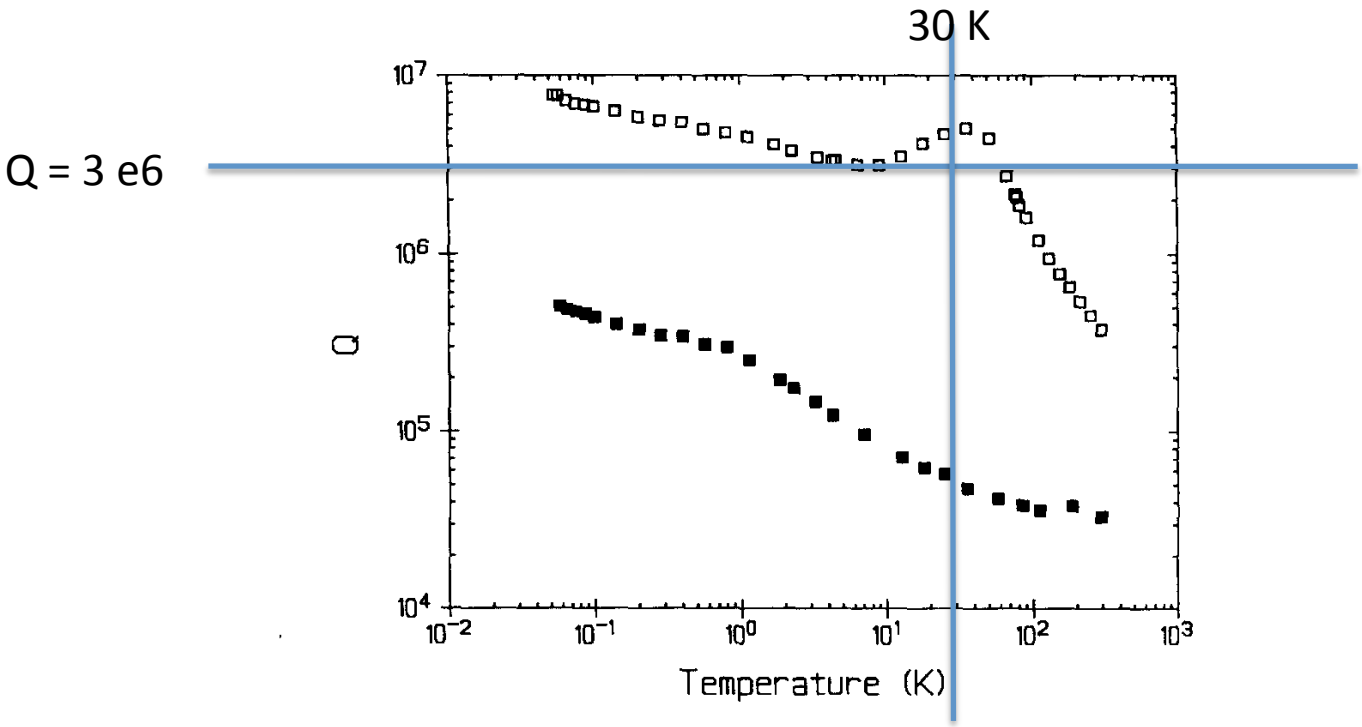


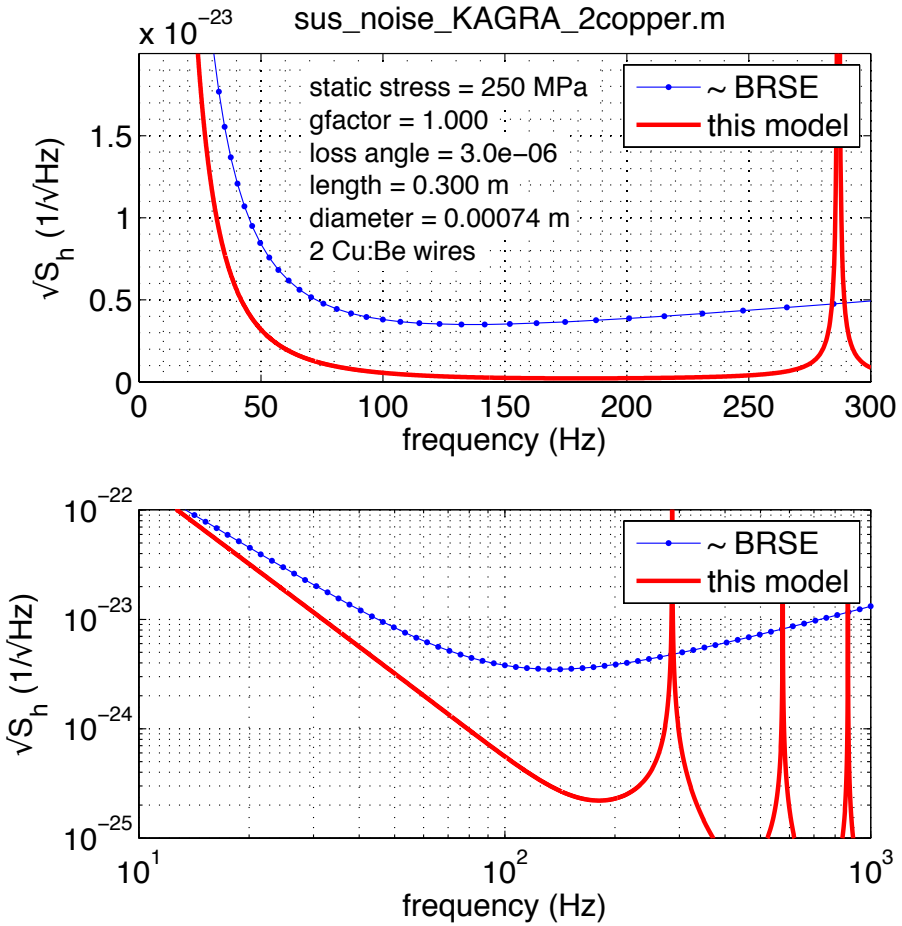
Figure 4 Quality factor *versus* temperature of beryllium copper. Data shown are for resonator: (■) as machined; (□) annealed

W. Duffy, Jr Cryogenics 1992 Vo132, No 12 pg1121

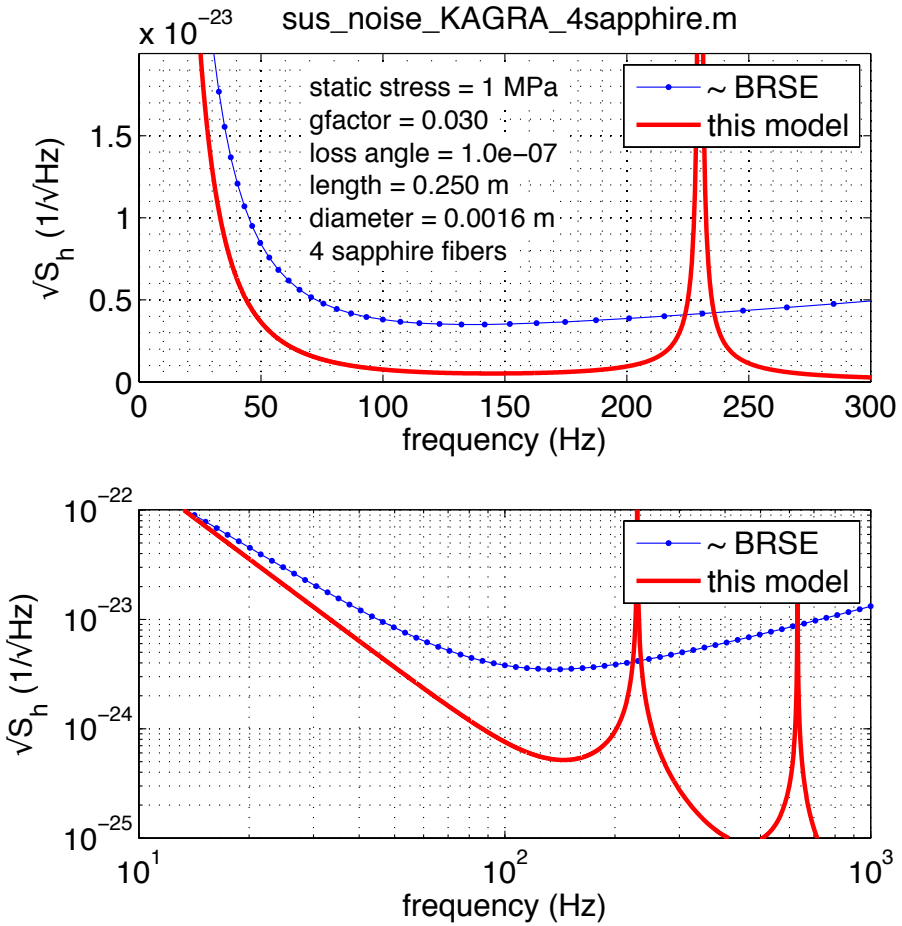
Today's strawman "3 member suspension"

- Cu:Be Suspension wires 1.0 meter long, phi = 3e-7 (Q = 3e6). Working stress = ¼ yield = 250 Mpa. Diameter = 0.7 mm
- Heat link dimensions: 1.6 mm thick, 4, 25 cm long.

Thermal noise for metal suspension



Thermal noise from (oversize?) heat link



Vertical suspension proposal: metal "torsion bar" suspension, like many old automobiles

- These have a *swing arm*, that rotates on a *bearing*, and a long *torsion bar* that is a torsion spring. The load is at the end of the swing arm.
  - Use *flex pivots* (small X pendula) as bearings for the swing arms.
  - Position each pivot at the conjugate point (eliminate percussion coupling) (a failure of flat blade springs?)
  - Use Cu:Be rods for torsion springs (high Q).
  - Need to solve a universal problem for cryogenic vertical suspensions:

    the temperature-offset of a vertical spring (they rise as they cool)

    use 1-2Hz suspension, not a SAS system.

Control issues

- Improved magnetic actuator:
  - uniform magnetic gradient coils
  - spherical magnet (no quadruple term)

  Together these reduce the parasitic magnetic vibration couplings by several orders of magnitude.
- Make detailed comparison of
  - New fiber optic coupled displacement sensors from attocube
  - Balanced capacitor bridge displacement sensors (similar to LISA sensors)

Next activity?

- Define a set of critical tests for the various concepts.