

**Zeitschrift:** Helvetica Physica Acta  
**Band:** 65 (1992)  
**Heft:** 2-3

**Artikel:** Zero applied force magnetic flux noise in Josephson junction arrays  
**Autor:** Lerch, Ph. / Leemann, Ch. / Théron, R.  
**DOI:** <https://doi.org/10.5169/seals-116449>

### **Nutzungsbedingungen**

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

### **Conditions d'utilisation**

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

### **Terms of use**

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

**Download PDF:** 06.08.2025

**ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>**

## ZERO APPLIED FORCE MAGNETIC FLUX NOISE IN JOSEPHSON JUNCTION ARRAYS

Ph. Lerch, Ch. Leemann, R. Théron, and P. Martinoli  
 Institut de Physique, Université de Neuchâtel, 2000 Neuchâtel, Switzerland

### Abstract

We present zero applied force magnetic flux noise occurring in a Josephson junction array ( $10^6$  junctions) as a function of temperature and applied static magnetic field. The spectral density of the flux noise power  $S_\phi(\nu, T)$  is  $1/\nu^\alpha$ -like with  $\alpha \approx 1$  in the range of our observation. As a function of temperature,  $S_\phi(4\text{Hz}, T)$  shows a peak which correlates with the dissipation peak observed in ac conductance measurements.

In a two-dimensional proximity effect Josephson junction array (JJA) thermal fluctuations of the phase of the superconducting wave function play a central role in governing the transition from the normal to the superconducting state. In particular, the thermally induced vortex-unbinding transition [1] has been studied extensively in experiments using magnetic [2] or electric [3] drive forces. In an applied normal magnetic field, expressed with the parameter  $f = \phi/\phi_0$  where  $\phi$  is the applied flux per unit cell of the array, the response of a JJA exhibits rich structures reflecting the interaction between the flux line lattice (FLL) and the pinning potential (PP) provided by the array. For rational values of  $f$ , the FLL is commensurate with the PP and merely pinned by the array. For  $f$  irrational, (or  $f = p/q$  with  $q$  large) the FLL is incommensurate with the PP and has therefore an increased mobility, leading to increased dissipation and decreased superfluid density.

For the study of vortex motion we propose the alternative method of measuring the spectral density of magnetic flux noise  $S_\phi(\nu, T)$  ( $\nu$  is the frequency,  $T$  the temperature) across the superconducting transition for various values of  $f$  without applying any drive field.

In this communication we present data for a JJA consisting of  $10^6$  Pb/Cu/Pb proximity effect junctions on a triangular lattice with lattice parameter  $L = 8\mu\text{m}$ . In order to first put the array in a known magnetic state we use our two-coil complex conductance technique [4] with an rf SQUID as a detector. An ac current in the drive coil induces screening currents in the sample. The receive coil, a superconducting first order gradiometer, is in series with the input coil of an rf SQUID system. A change in the sample's conductance induces a change in the coils' mutual inductance which is detected by the SQUID. Then, in order to measure  $S_\phi(\nu, T)$  the drive coil is disconnected. The SQUID (operated in the flux-locked-loop mode) output is proportional to the total flux through the detection coil, which, in turn is proportional to the flux in the array. If one neglects the very small field applied to the sample across the feedback circuit of the SQUID, there is no externally applied driving force and the array, at least for a rational  $f$ , is in an equilibrium state.

The upper curve in Fig. 1 shows the spectral density  $S_\phi(\nu, T)$  as a function of frequency measured at 3.47 K. The superconducting transition temperature at  $f = 0$  is measured inductively to be at 3.77 K. The lower curve provides the reference background noise measured at 4.5 K. A clear  $\nu^{-\alpha}$ ,  $\alpha \approx 1$  dependence can be observed between 0.1 and 100 Hz. Above 100 Hz background noise dominates.

On the left-hand scale of Fig. 2 we show the result of an ac complex conductance measurement performed at 160 Hz for  $f = 1/2$  as a function of temperature. The roll-off measures mainly the superfluid density whereas the peak is related to the dissipation in the sample. On the right-hand scale  $S_\phi(\nu = 4\text{Hz}, T)$  is presented. The background noise was subtracted. The frequency dependence is similar to the one shown in Fig. 1, the exponent  $\alpha \approx 1$  not being significantly temperature dependent.

To conclude this preliminary report, zero drive force magnetic flux noise correlates (in temperature) with the dissipation observed when the sample is driven. The fact that we see magnetic flux noise in the critical region is not a surprise. However, these results are different from those obtained in flux flow noise experiments where at least 100 times more vortices are subject to a substantial drive current. We believe that in the  $f = 0$  case the noise arises from the motion of thermally activated vortices and maybe from lattice or additional defects in the  $f = 1/2$  case. Noise figures in these two cases are almost equivalent, however. Similar magnetic flux noise has been observed by Ferrari et al [5] in high temperature superconducting films which are highly disordered systems compared to a periodic JJA.

We would like to acknowledge R. Meyer for providing a new superconducting detection coil. This work was supported by the Swiss National Science Foundation.

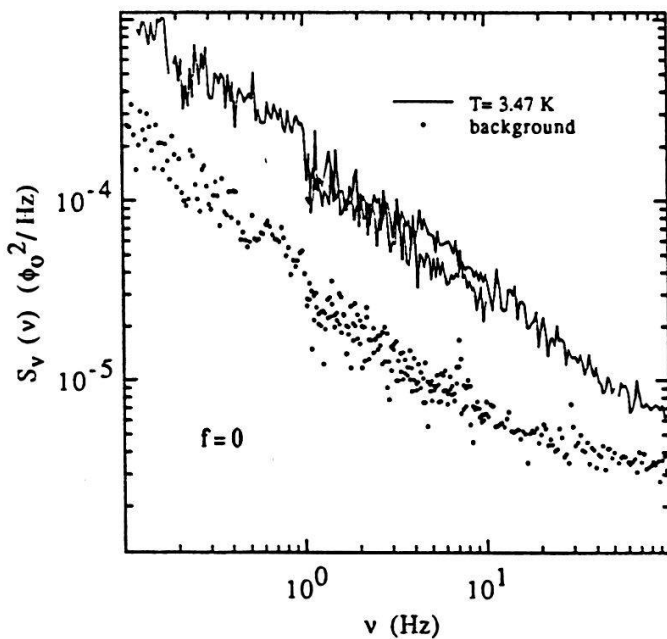


Figure 1: a) Spectral density of  $S_\phi(\nu, T = 3.47)$  of a JJA (noise floor not subtracted). b) Same quantity measured above the transition.

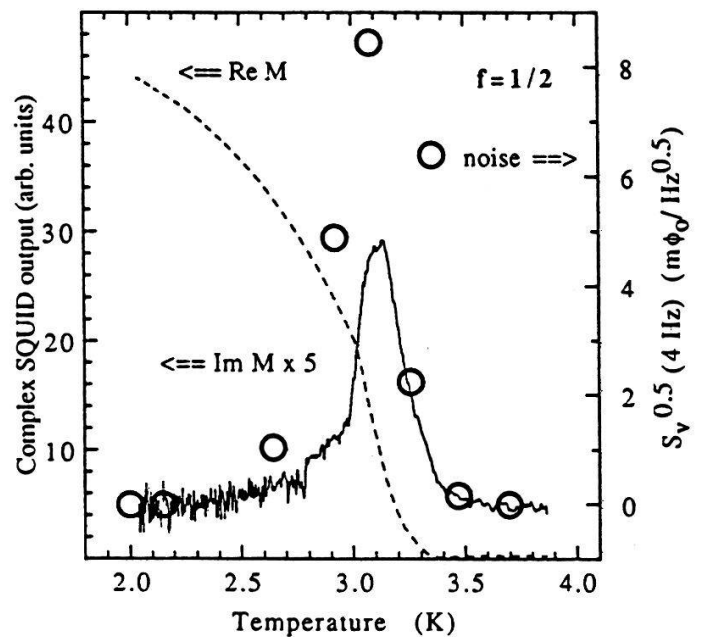


Figure 2: Response (left hand scale) of an ac shielding measurement as a function of temperature. On the right hand scale magnetic flux noise  $S_\nu(\nu = 4\text{Hz}, T)$ .

- [1] J.M. Kosterlitz and D.J. Thouless *J. Phys. C* **6**, 1181 (1973) and V. Ambegaokar, B.I. Halperin, D.R. Nelson, and E.D. Siggia, *Phys. Rev. Lett.* **40**, 783 (1978).
- [2] Ph. Lerch, Ch. Leemann, R. Théron, and P. Martinoli, *Phys. Rev. B* **41**, 11579 (1990).
- [3] M.S. Rzchowski, S.P. Benz, M. Tinkham, and C.J. Lobb, *Phys. Rev. B* **42**, 2041 (1990).
- [4] B. Jeanneret, J.L. Gavilano, G.A. Racine, Ch. Leemann, and P. Martinoli, *Appl. Phys. Lett.* **55**, 2336 (1989).
- [5] M.J. Ferrari, M. Johnson, F.C. Wellstood, J. Clarke, A. Inam, X.D. Wu, L. Nazar, and T. Venkatesan, *Nature* **341**, 723 (1989).