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CONCERNING THE FERMI SURFACE OF TIN

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It is shown that besides the model of the Fermi surface for tin proposed earlier,[1] another topologically equivalent surface satisfies the experimental data from galvanomagnetic measurements. The surface suggested is compared with the Fermi surface derived by Gold and Priestley[2] from a study of the de Haas–van Alphen effect.

We reported earlier[1] that some general deductions could be made about the form of the Fermi surface of tin on the basis of a study of the galvanomagnetic properties.

Recently Gold and Priestley[2] reported the results of an investigation of the Fermi surface of tin obtained by measuring the de Haas–van Alphen effect. It was therefore of interest to compare the results of these two methods of studying the Fermi surface of metals.

The main experimental result of galvanomagnetic measurements is a stereographic projection of the singular magnetic field directions.[3] A unique interpretation of this projection is not always possible. The stereographic projection we obtained previously[1] made possible the following proposed model of an open Fermi surface: a plane net of "corrugated cylinders" with axes parallel to the [010] direction. The dimensions of the "cylinders" are such that [110] is an additional open direction.

However, along with such a surface, the stereographic projection of the singular magnetic field directions for tin can agree with an open Fermi surface formed by "corrugated cylinders" with axes directed along [110]. The [010] direction is then the additional open direction.

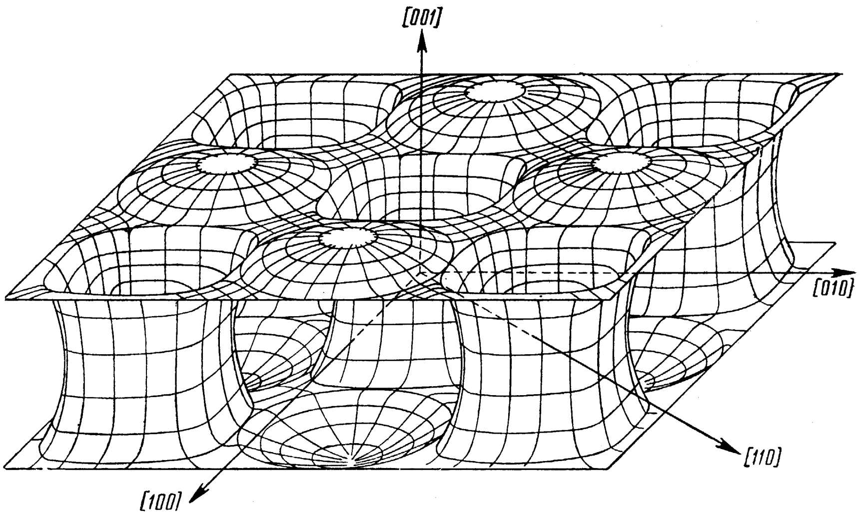
This surface, as well as the surface discussed above, is equivalent, in a topological way, to a surface formed by two corrugated planes, parallel to the (001) plane and connected in the [001] direction by tubular "bridges." The mean diameter of the "bridges" can be calculated by using the experimental data and Eqs. (3) and (4) of the previous paper[1]: $d = 0.55\,b$ and the mean distance between the planes: $h = 0.5\,b$, where $b = 2\,(2\pi/a)$, $a = 5.84$ A. An open surface of this type is shown schematically in Fig. 1.

Both variants of an open Fermi surface for tin are topologically equivalent and can be obtained, one from the other, by rotating the axes through an angle $\pi/4$ in the (001) plane and changing the scale by a factor $\sqrt{2}$.*

From the experimental data it also follows that tin has a closed surface (or several surfaces), with a volume equal to the volume of the open surface, but of opposite sign. According to measurements of the Hall effect the closed surface corresponds to "electrons" and the open to "holes." Using the value of the Hall constant in the [001] direction, $R_{[001]} = 5 \times 10^{-3}$ cgs emu, the volume of the "bridges" can be calculated, which agrees with the principal dimensions of the open surface. This is the model of the Fermi surface of tin which results from the galvanomagnetic data.

Gold and Priestley proposed a model, according to which the Fermi surface of tin consists of seven closed and two open surfaces, the closed surfaces (except for one) being "electronic" and the open, "hole." The total volumes of the "electron" and "hole" surfaces are roughly equal. Gold and Priestley found that the results of their experiments on the de Haas–van Alphen effect could be explained within the framework of this

*The Bravais lattice of tin can be chosen in two ways: it is either a face-centered tetragonal lattice with axial ratio $a/c \approx 2.6$, or a body-centred tetragonal lattice with axial ratio $a/c \approx 1.8$. Both lattices are equivalent in principle and differ from one another in that their periods in the (001) plane differ by $\sqrt{2}$. In the previous paper the analytic expression for the isoenergetic surfaces is given in the axial system of a face-centred tetragonal crystal lattice, while the axial ratio a/c for tin was given in error for a body-centred lattice ($a/c \approx 1.8$). However, for the qualitative analysis of the topology of the isoenergetic surfaces only the property that $a/c > 1$ was used, and not the quantitative expression for a/c.



model. There is thus a qualitative agreement between the two models of the Fermi surface of tin considered.

We can only make a quantitative comparison for the open surfaces. Of the two open surfaces in Gold and Priestley's model we must choose that which lies in the fourth Brillouin zone, since a surface in the third zone cannot give anything new for the galvanomagnetic properties.

The open surface is the fourth zone consists of two "corrugated planes," joined by "bridges" in the [001] direction. This surface agrees topologically with both variants of the Fermi surface proposed by us. It agrees approximately in shape with the surface shown in Fig. 1. The difference between these surfaces consists only in the first having the [110] direction open, while the second has both the [110] and the [010] directions open. However, this difference is insignificant since, keeping the cross-section area of the "bridges" constant, it is possible by small "deformation" of this cross-section to make the [010] direction open as well. The area of certain sections of the surface in the fourth zone can be calculated from the values of the periods of the oscillation of susceptibility determined by Gold and Priestley, and its characteristic dimensions can then be found. The diameter of the "bridges" and the distance between the "planes" are roughly equal to 0.5b.

The Fermi surface of tin obtained on the basis of the data of galvanomagnetic measurements is thus in good agreement with the surface derived by Gold and Priestley.

We should also remark that the topological type of open surface suggested earlier[1] and in the present work is shown up in experiments on magnetoacoustic resonance,[4] in which, in particular, open trajectories along the [110] direction are found.

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