

A Shielding Device for Shielding a Device from Electromagnetic Noise

Technical Field

The present disclosure relates to a shielding device for shielding a magnetically sensitive device, such as a quantum device, from electromagnetic noise. The disclosure also relates to a shielding assembly comprising a plurality of shielding devices, and to a shielded quantum processing unit, as well as a quantum apparatus, such as a quantum computer, comprising such a shielding assembly.

Technical Background

Magnetically sensitive devices, such as quantum devices, need to be shielded from electromagnetic noise because they are extremely sensitive to their environment. Such noise can be present in the form of an electromagnetic field, and/or in the form of radiation and, without adequate shielding, can interfere with the state of these devices, leading to errors, loss of information, and reduced performance.

For example, a class of magnetically sensitive devices are quantum devices, and for example superconductive devices that require particularly efficient shielding from noise. In accordance with the prior art, it is known to provide a shielding packaging for such quantum devices, or even a double shielding packaging.

US 2021/0068320 A1 describes shielding devices including a multilayer enclosure that comprises a superconducting material with a thickness that reduces the penetration of magnetic fields into the multilayer enclosure.

Despite the advances in terms of shielding devices for quantum devices, there is a need for further improvements. For example, shortcomings are associated with volumetric sizes that are higher than desirable or with difficulties associated with maintenance, such as, e.g., maintenance being time consuming.

Moreover, efficient shielding often requires producing large quantities of metal plates, and the manufacturing is time consuming and costly, as well as rendering a shielding devices heavy.

There is, hence, a need for an improved shielding that addresses at least one of the above-mentioned shortcomings. It would also be desirable to have improved shielding assemblies comprising a plurality of shielding devices, as well as quantum processing units and quantum computers improved in terms of their shielding with respect to noise.

Summary

Aspects of the above-mentioned object are achieved by a shielding device for shielding a magnetically sensitive device from electromagnetic noise in accordance with the present disclosure.

One aspect of the present disclosure relates to a shielding device for shielding a device from electromagnetic noise. The shielding device comprises a main shield body that partially encapsulates an interior space and comprises an opening that provides access to the interior space. A part of the interior space may be an accommodating space for accommodating a magnetically sensitive device, in particular a quantum device.

The shielding device may comprise a lid that covers (or is configured to cover) the main shield body. The lid may comprise a lid opening, through which the interior space of the shielding device is accessible.

The shielding device may comprise at least one shield member that is located in the interior space and, specifically, between the opening and the accommodating space. The location between the opening and the accommodating space may promote the shielding effectivity, as the opening or, in particular the lid opening, is where noise headed towards the accommodating space exclusively or primarily originates from.

The at least one shield member may be structurally distinct and/or separable from the main shield body. Being structurally distinct from the main shield body in this context means not being integrally formed together with the main shield body as to be one and the same structure with the rest of the main shield body. Being structurally distinct thus means that the at least one shield member was manufactured on its own and independently from the main shield body. A structurally distinct shield member may be built into the interior space of the main shield body and may remain there for the lifetime of the entire shielding device, or, for other cases, it may be reversibly removed or replaced, i.e., it may be separable from the main shield body. The expression "separable from" in this context means that the shield member can be separated from the main shield body (e.g., taken out of the main shield body) without any substantial damage.

The at least one shield member may be separable and may in particular be reversibly separable from the main shield body. Moreover, the at least one shield member may be separated from the main shield body or not separated therefrom when built into the interior of the main shield body.

The separability of the at least one shield member from the main shield body may further improve the maintenance of the shielding device and/or a magnetically sensitive device mounted in the accommodating space of the shielding device.

The shield member may comprise at least a high permeability layer with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a low permeability layer that is superconductive when cooled below a critical temperature, wherein the high permeability layer is provided between the opening and the low permeability layer.

Electromagnetic fields and/or radiation entering the interior space and propagating towards the accommodating space will be exposed to the at least one shield member due to the location between the opening and the accommodating space. In addition, as the high permeability layer is provided between the opening and the low permeability layer, the fields and/or radiation may be diverted efficiently by the high permeability layer. In other words, the high permeability layer may extract a flux and re-direct it away from the accommodating space.

The superconductive material layer may in turn prevent flux from transitioning deeper inside of the interior space and towards the accommodating space.

An aspect of the present disclosure relates to a shielding device that shields a magnetically sensitive device from electromagnetic noise. The shielding device comprises a main shield body that partially encapsulates an interior space and is provided with an opening that provides access to the interior space, with a part of the interior space being an accommodating space that accommodates a magnetically sensitive device, at least one shield member that is located in the interior space, that is structurally distinct and/or separable from the main shield body, and between the opening and the accommodating space, wherein the shield member comprises at least a high permeability layer with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a low permeability layer that is superconductive when cooled below a critical temperature, and the high permeability layer is provided between the opening and the low permeability layer.

The low permeability layer that is superconductive when cooled below a critical temperature may also be referred to as a superconductive material layer.

The shielding device may comprise a plurality of shield members located in the interior space and between the opening and the accommodating space.

An aspect of the present disclosure relates to a shielding device that shields a quantum device from electromagnetic noise, the shielding device comprising a plurality of shield members located in the interior space and between the opening and the accommodating space, wherein, two or more, optionally all, of the plurality of shield members comprise a respective high permeability layer with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a respective superconductive material layer that is superconductive when cooled below a critical temperature, and the respective high permeability layer is provided between the opening and the respective superconductive material layer of the respective shield member.

A plurality of shield members may be two shield members or more than two shield members. A plurality of shield members may, for example, be from 2 to 8 shield members or from 3 to 7 shield members.

Additional shield members may further promote the shielding effect against electromagnetic field flux and/or radiation penetrating further into the shielding device and towards the accommodation space.

Two or more of the plurality of shield members may each comprise a respective high permeability layer with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a respective superconductive material layer that is

superconductive when cooled below a critical temperature. All of the plurality of shield members may each comprise a respective high permeability layer with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a respective superconductive material layer that is superconductive when cooled below a critical temperature.

Pairs of high and superconductive material layers in accordance herewith may particularly efficiently promote shielding against fields and radiation reaching the accommodation space.

For each of the plurality of shield members comprising the high permeability layer and the superconductive material layer, the respective high permeability layer is provided between the opening and the respective superconductive material layer of the respective shield member. In other words, the plurality of shield members may be arranged together to comprise alternating pairs of high permeability layers and superconductive material layers.

Alternating pairs of the high and superconductive material layers may particularly efficiently promote shielding against fields and radiation reaching the accommodation space.

The high permeability layer and the superconductive material of a shield member (of one of them, or two or more, or of all of them) may be provided on top of one another. Alternatively, a gap may be provided between them. Another alternative is that one or several other layers are provided in-between.

The high permeability layer and the superconductive material layer of a shield member (of one of them, or two or more, or of all of them) may be glued together and/or screwed together.

Adjacent shield members may be connected by a mechanical support.

When the shielding device comprises a plurality of shield members, a field and/or radiation flux may be reduced at each shield member.

The shield members may have openings permitting wire connectivity and mechanical structures to go through. This way, wire connectivity and/or mechanical support may be provided to the device located in the accommodation space in a convenient way for the accommodation space and for other parts of the interior space of the shielding device.

However, openings may permit field and/or radiation flux to enter deeper into the interior space of the shielding device. To prevent this, each shield member may comprise a high permeability layer that extracts some field and/or radiation flux. In other words, each high permeability layer may extract some flux and re-direct it away from the accommodating space inside the interior space of the shielding device. Moreover, every superconductive material layer, following a neighboring high permeability layer, may prevent flux from transitioning further inside the shielding device. An alternating arrangement of high and superconductive material layers may, hence, be particularly effective in preventing flux from penetrating further inside of the interior space and towards the accommodating space of the shielding device.

According to some aspects, the high permeability layer and the superconductive material layer may be separated by a gap.

At least two shield members of the plurality of shield members may structurally differ from one another. Put differently, at least two shield members may not be structurally identical. For example, they may differ in terms of the number of and/or the composition of layers, or they may have layers with different thicknesses, or their size may differ. The structural differences may reflect a finetuning of the compositions and functionalities of the shield members for different locations

within a shielding device.

At least two shield members of the plurality of shield members may structurally differ in terms of the high permeability layer and the superconductive material layer of the shield member. In other words, the high permeability layer of one shield member may be different from the high permeability layer of another shield member. In addition or alternatively thereto, the superconductive material layer of one shield member may be different from the superconductive material layer of another shield member.

At least two shield members of the plurality of shield members may be structurally the same.

Several or all of the plurality of shield members may be structurally the same.

A relative electromagnetic permeability of the high permeability layer of the at least one shield member may be in a range of $1.5 \cdot 10^5$ to $2.5 \cdot 10^5$ Henries.

A relative electromagnetic permeability of the high permeability layer of the at least one shield member may be in a range of $1.8 \cdot 10^5$ to $2.2 \cdot 10^5$ Henries.

A relative electromagnetic permeability of the high permeability layer of at least one of the plurality of shield members may be in a range of $1.5 \cdot 10^5$ to $2.5 \cdot 10^5$ Henries.

A relative electromagnetic permeability of the high permeability layer of at least one of the plurality of shield members may be in a range of $1.8 \cdot 10^5$ to $2.2 \cdot 10^5$ Henries.

A relative electromagnetic permeability of the high permeability layer of several of the plurality of shield members may be in a range of $1.5 \cdot 10^5$ to $2.5 \cdot 10^5$ Henries.

Thereby, the relative electromagnetic permeability of each of the several high permeability layers of the several of the plurality of shield members may be the same, or some or all of them may mutually differ.

A relative electromagnetic permeability of the high permeability layer of several of the plurality of shield members may be in a range of $1.8 \cdot 10^5$ to $2.2 \cdot 10^5$ Henries. Thereby, the relative electromagnetic permeability of each of the several high permeability layers of the several of the plurality of shield members may be the same, or some or all of them may mutually differ.

A relative electromagnetic permeability of the high permeability layer of all of the plurality of shield members may be in a range of $1.5 \cdot 10^5$ to $2.5 \cdot 10^5$ Henries. Thereby, the relative electromagnetic permeability of each of the high permeability layers of all of the plurality of shield members may be the same, or some or all of them may mutually differ.

A relative electromagnetic permeability of the high permeability layer of all of the plurality of shield members may be in a range of $1.8 \cdot 10^5$ to $2.2 \cdot 10^5$ Henries. Thereby, the relative electromagnetic permeability of each of the high permeability layers of all of the plurality of shield members may be the same, or some or all of them may mutually differ.

The plurality of shield members may consist of from 2 to 7 shield members. The plurality of shield members may consist of from 3 to 6 shield members. The plurality of shield members may consist of from 3 to 5 shield members. The increasingly narrower ranges of total numbers of shield members may offer increasingly desirable compromises between limiting the volumetric size and the gain in shielding efficiency by adding shielding members.

A distance between adjacent shield members may be in a range of three times the diameter of the hole for letting the mechanical structure and/or cables pass through or less. Optionally, the distance may be twice the diameter or less.

The term adjacent refers to the property of being direct neighbors. In particular, shield members may be provided one after another in a direction starting from the opening of the shielding device and heading towards the accommodation space. The shield member closest to the opening is, hence, adjacent to the shield member 2nd closest to the opening. The shield member furthest away from the opening is adjacent to the shield member 2nd furthest from the opening. All of the shielding members in-between are adjacent to the two shield members between which they are sandwiched in terms of position when looking in the direction from the opening to the accommodation space.

A thickness of the high permeability layer of the at least one shield member may be in a range of 0.2 mm to 3mm, in particular sufficient to not saturate with the magnetic field. It may be in a range of 0.2 mm to 1.5 mm or 0.7 mm to 1.3 mm or 0.8 mm to 1.2 mm.

A thickness of the high permeability layer of any of the plurality of shield members may be in a range of 0.2 mm to 3 mm. It may be in a range of 0.2 mm to 1.5 mm or 0.7 mm to 1.3 mm or 0.8 mm to 1.2 mm.

A thickness of the high permeability layer of several of the plurality of shield members may be in a range of 0.2 mm to 3 mm. It may be in a range of 0.2 mm to 1.5 mm or 0.7 mm to 1.3 mm or 0.8 mm to 1.2 mm.

A thickness of the high permeability layer of all of the plurality of shield members may be in a range of 0.2 mm to 3 mm. It may be in a range of 0.2 mm to 1.5 mm or 0.7 mm to 1.3 mm.

mm or 0.8 mm to 1.2 mm.

A thickness of the superconductive material layer of the at least one shield member may be in a range of 0.2 mm to 3mm. It may be in a range of 0.2 mm to 1.5 mm or 0.7 mm to 1.3 mm or 0.8 mm to 1.2 mm.

A thickness of any one or several, or optionally of all of the plurality of shield members may be a range of 0.2 mm to 3mm, optionally in a range of 0.2 mm to 1.5 mm or 0.7 mm to 1.3 mm or 0.8 mm to 1.2 mm.

The at least one shield member of the plurality of shield members may comprise a mechanical support layer, on which the superconductive material layer is at least partially fixed.

Any one or several, or all of the plurality of shield members comprise a mechanical support layer, on which the superconductive material layer is at least partially fixed.

Any one or several, or all of the mechanical support layer(s) may comprise copper.

Any one or several, or all of the mechanical support layer(s) may be a mechanical support plate.

A surface of the high permeability layer of the at least one shield member and/or of any one or several, or optionally all, of the plurality of shield members may be oriented towards the opening.

Being oriented towards the opening means does not necessarily mean directly facing the opening, but it can also mean indirectly facing the opening. For example, one shield member may be oriented towards the opening, but another shield member (or several shield members or other components) may be in-between the one shield member and the opening.

When a high permeability layer of the shield member is plate-shaped, being oriented towards the opening implies that the main surface (a plate-shaped surface) of the high permeability layer of the shield member faces the opening. It may face the opening at 90 degrees or at another angle. For example, a high permeability layer (e.g., a high permeability plate) may be parallel to the opening, or it may be angled with respect to a surface in which the opening lies.

In contrast a high permeability layer that is oriented such that its main surfaces extend away from an opening in which the surface lies at an angle of 90 degrees would not be oriented towards the opening. Being oriented towards the opening may be referred to as facing the opening or indirectly facing the opening (when there are one or several other component in-between) with a surface (a main planar surface of the high permeability layer when the latter is plate-shaped).

The high permeability layer may be parallel to the opening.

A surface of the superconductive material layer of the at least one shield member and/or of any one or several, or optionally all, of the plurality of shield members may be oriented towards the opening.

Being oriented towards the opening means does not necessarily mean directly facing the opening, but it can also mean indirectly facing the opening. For example, one shield member may be oriented towards the opening, but another shield member (or several shield members or other components) may be in-between the one shield member and the opening.

When a superconductive material layer of the shield member is plate-shaped, being oriented towards the opening implies that the main surface (a plate-shaped surface) of the superconductive material layer of the shield member faces the

opening. It may face the opening at 90 degrees or at another angle. For example, a superconductive material layer (e.g., a superconductive material plate) may be parallel to the opening, or it may be angled with respect to a surface in which the opening lies.

In contrast a superconductive material layer that is oriented such that its main surfaces extend away from an opening in which the surface lies at an angle of 90 degrees would not be oriented towards the opening. Being oriented towards the opening may be referred to as facing the opening or indirectly facing the opening (when there are one or several other component in-between) with a surface (a main planar surface of the superconductive material layer when the latter is plate-shaped).

The superconductive material layer may be parallel to the opening.

The shielding device may comprise an outermost shield member that comprises at least an outermost high permeability layer with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and an outermost superconductive material layer that is superconductive when cooled below a critical temperature. The outermost high permeability layer may form the lid or a part of the lid of the shielding device.

The outermost shield member may be the shield member amongst the plurality of shield members that is the farthest located from the accommodation space.

The outermost high permeability layer may be located at a boundary of the interior space or outside of the interior space.

The location at the boundary of the interior space refers to a location where the interior space of the shielding device

ends. Thus, the outermost high permeability layer may be located partially or fully inside of the interior space, and it may be located partially or fully outside of the interior space.

The outermost high permeability layer may at least partially close the opening.

A clearance gap may be present between the at least one shield member and the main shield body. The clearance gap may be in a clearance range, meaning the at least one shield member and the main shield body may be considered slightly touching so that sliding may be possible without scratching / damaging the materials. The clearance gap may have a width of around 1.5mm, but the width may, more generally, be of the order of 3mm or less.

Any one or several, or all of the plurality of shield members may not contact the main shield body, wherein a respective clearance gap may have a width of up to 3 mm, optionally up to 1.5 mm.

The at least one shield member and/or of any one or several, or optionally all, of the plurality of shield members may comprise(s) at least one opening to allow for a supporting structure, and/or a cable to pass through the at least one shield member, or any one or several, or all, of the plurality of shield members.

For example, shield members may be plate-shaped and may comprise openings located at mutually different locations or at mutually same locations, e.g., centrally in the plate or at a different position, such that a cable or a supporting structure can consecutively pass through every shield member or plate. This way, a cable or a supporting structure or both can pass from the opening to the accommodating space and, e.g., support a quantum device and/or transmit signals thereto and

therefrom and/or supply the quantum device with energy. This way, support and cable supply may be provided while minimizing any detrimental effects on the shielding of fields and/or radiation reaching the quantum device.

The at least one shield member may comprise a metal-containing plate and a superconductive plate, wherein the metal-containing plate of the at least one shield member may comprise the high permeability layer, and the superconductive plate of the shield member may comprise the superconductive material layer.

Optionally, the metal-containing plate of the at least one shield member consists of the high permeability layer.

Optionally, the superconductive plate of the at least one shield member consists of the superconductive material layer.

Optionally, any one or several, optionally all, of the plurality of shield members comprise a respective metal-containing plate and a respective superconductive plate, wherein, for any one or several, optionally all, of the plurality of shield members, the respective metal-containing plate comprises the high permeability layer and the respective superconductive plate comprises the superconductive material layer.

For any one or several, optionally all, of the plurality of shield members, the respective metal-containing plate may consist of the high permeability layer.

For any one or several, optionally all, of the plurality of shield members, the respective superconductive plate may consist of the superconductive material layer.

The superconductive layer of the at least one shield member may comprise any one or more than one of the materials selected

from the list consisting of: indium, rhenium, yttrium barium copper oxide, tin (Sn), aluminum (Al), titanium nitride (TiN), titanium (Ti) and Nb.

When the shielding device comprises a plurality of shield members, the superconductive layer of any one or several, or optionally all, of the plurality of shield members may comprise any one or more than one of the materials selected from the list consisting of: indium, rhenium, yttrium barium copper oxide, tin (Sn), aluminum (Al), titanium nitride (TiN), titanium (Ti) and Nb. The superconductive layers of different shield members may comprise the same materials. Alternatively, the superconductive layers of different shield members may differ in terms of material. For example, the superconductive layer of a first shield member may comprise different materials than the superconductive layer of a second shield member, or the superconductive layer of a first and the superconductive layer of a second shield member may partially comprise the same materials and partially different materials.

The high permeability layer of the at least one shield member may comprise any one or more than one of the materials selected from the list consisting of: Cryophy, Cryperm, Tokin R, A4K, other cryogenic compatible high permeability materials, typical of hi Ni-iron alloys ("hi" stands for high content).

When the shielding device comprises a plurality of shield members, the high permeability layer of any one or several, or optionally all, of the plurality of shield members may comprise any one or more than one of the materials selected from the list consisting of: Cryophy, Cryperm, A4K, Tokin R, and other cryogenic compatible high permeability materials, typical of hi Ni-iron alloys.

The main shield body may comprise side walls and a bottom wall and the opening may be provided on an end of the shielding device that is remote from the bottom wall. The bottom wall

being located at an end side of the shielding device, a top wall may be provided at the other end side of the shielding device, and the opening may be provided in the top wall. Alternatively, the shielding device may not comprise such a top wall, and the opening may be provided by virtue of the absence of the top wall so that the shielding device is open at the end side that is opposite to the one end side where the bottom wall is provided.

The main shield body may be cylindrically shaped, and the shielding device may be open on one side, either on the top side or on the bottom side. Alternatively, a side surface of the shielding device may comprise the opening.

The main shield body may comprise at least one of a high permeability layer with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a superconductive material layer that is superconductive when cooled below a critical temperature.

Any side wall or other part of the main shield body may comprise at least one of a high permeability layer with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a superconductive material layer that is superconductive when cooled below a critical temperature. Different walls and/or parts of the main shield body may comprise the same materials or they may mutually differ in terms of material composition.

A high permeability layer of the main shield body may face towards the outside of the shielding device, and a superconductive material layer of the main shield body may face the interior space of the shielding device. Hence, the superconductive material layer is located in between the high permeability layer and the interior space of the shielding device.

A superconductive material layer, optionally, a superconductive layer, may be provided on at least one of the inside walls of the side walls and/or bottom wall of the main shield body that is exposed to the interior space on at least a part of the inside wall, optionally on the entire inside wall. This may particularly efficiently promote the shielding by the shielding device.

The superconductive material layer may be provided on at least one of the inside walls of the side walls and/or a bottom wall of the main shield body and may be provided in at least a part of the accommodating space.

There may be no superconductive material layer provided on at least a part of the inside walls and/or a part of the bottom wall of the main shield body.

Another aspect of the present disclosure relates to a shielding assembly that comprises a plurality of shielding devices, wherein the shielding devices are in accordance with any of the shielding devices described above. The shielding devices may be the same or they may differ.

The plurality of shielding devices may be consecutively inserted into one another, from an outermost shielding device to an innermost shielding device.

Another aspect of this disclosure relates to a shielded quantum processing unit comprising a shielding device in accordance with any one or several features described above, as well as a quantum processing unit provided in the accommodation space.

Another aspect of this disclosure relates to a quantum device comprising a shielding device in accordance with any one or several features described above and/or the shielding assembly in accordance with any one or several features described above. The quantum device is, for example, a quantum computer.

Additional advantages and features of the present disclosure, that can be realized on their own or in combination with one or several features discussed above, insofar as the features do not contradict each other, will become apparent from the following description of particular embodiments.

Brief Description of the Drawings

For a better understanding of the present disclosure and to show how the same may be carried into effect, reference will now be made, by way of example only, to the accompanying figures:

Fig. 1A is a shielding device in accordance with the present disclosure;

Fig. 1B is a shielding device in accordance with the present disclosure;

Fig. 1C is a shielding device in accordance with the present disclosure;

Fig. 1D is a shielding device in accordance with the present disclosure, wherein the main shield body comprises a high permeability layer;

Fig. 2 illustrates the propagation of electromagnetic noise inside of a shielding device in accordance with the present disclosure;

Fig. 3 is a shielding device in accordance with the present disclosure;

Fig. 4A is a schematic perspective view of a shielding assembly in accordance with the present disclosure;

Fig. 4B is a sectional view of the shielding assembly of Fig. 4A.

Fig. 4C is a sectional view of an embodiment of a shielding assembly according to the disclosure;

Fig. 5A depicts a shielding assembly in accordance with the present disclosure;

Fig. 5B represents experimental results concerning the shielding effect achieved at different locations surrounding and inside the shielding assembly of Fig. 5A; and

Fig. 5C represents experimental results concerning the shielding effect achieved at different locations surrounding and inside the shielding assembly of Fig. 5A.

Fig. 1A shows a schematic view of a shielding device 1 in accordance with the present disclosure. The shielding device 1 is for shielding a magnetically sensitive device from electromagnetic noise.

The shielding device 1 comprises a main shield body 10 that, together with a lid 11, encapsulates an interior space 12. The shielding device 1 comprises an opening 40 that provides access to the interior space 11. In the case of the embodiment of Fig. 1A, a lid 12 covers the opening 11, but itself has a central opening which allows cables and a support structure 60 to pass through.

A part of the interior space 12 is also specifically referred to as an accommodating space 30 for accommodating a device, such as, in particular, an electromagnetically sensitive device. In other words, an electromagnetically sensitive device may be provided in the accommodating space 30. The partial encapsulation of the interior space by the main shield body 10 means that the main shield body 10 does not fully / completely surround the interior space 12. However, as mentioned above, a lid 11 is in this case closing the opening 11.

The main shield body 10 of the shielding device 1 of Fig. 1A may be cylindrically shaped and comprise side walls and a bottom wall, while there may be no upper wall or surface. The open top may, hence, in this case constitute the opening 11 that may provide access to the interior space 12. As mentioned above, the shielding device 1 may optionally comprise a lid 11 comprising an opening or openings for cables and/or support mechanical structure 60. A support structure 60 enables to connect the sensitive magnetic device 50 to external components of the shielding device 1, in particular being a vertical mechanical connection to elements located on the top and outside of the shielding device 1.

A magnetically sensitive device 50 that may be placed in the accommodation space 30 may, for example, be a quantum device. The magnetically sensitive device 50 may, for example, be a Traveling Wave Parametric Amplifier (TWPA). A quantum device is a device using principles of quantum physics to, for example, perform a computational, informational, communication or measurement task. A quantum device may, e.g., be one of a quantum computer, a quantum processor, a quantum sensor, a quantum limited amplifier, a quantum key distribution system, a quantum random number generator, a quantum communication system, a quantum annealer, a quantum simulator, and a quantum cryptography device.

Fig. 1A generically shows a magnetically sensitive device 50 using dots lines. This magnetically sensitive device 50 may be for example a quantum device that may be provided in the accommodating space 30 and may be shielded by the shielding device 1.

In Fig.1A ,a shield member 20 is located in the interior space 12. It is connected to a mechanical support 60, for example bolted to a main axis of the support (which may include wire guides) of the shield device 1, so that it is stably mounted and held in place. On Fig. 1A, the mechanical support 60 is a central support being located in the center of the shield member. However, the mechanical support 60 can be located anywhere within the shield device 1.

According to Fig. 1A, the shield member 20 may be structurally distinct from the main shield body 10. It may also be separable from the main shield body 10. It may namely be built in and out. That is, it may be removed from the interior space without being damaged and without damaging the main shield body 10. The shield member 20 may also be referred to as a baffle.

As reflected by Fig. 1A, the shield member 20 does not touch the main shield body 10. The shield member is located at a distance of the side walls of the shield body 10. This may further prevent the penetration of electromagnetic field deeper into the shielding device 1. A clearance gap may be present between the shield member 20 and the main shield body 10. The clearance gap may be in a clearance range, meaning the shield member 20 and the main shield body 10 may be considered slightly touching so that sliding may be possible without scratching / damaging the materials. The clearance gap may have a width of around 1.5mm, but the width may, more generally, be of the order of 3mm or less.

In the case of the embodiment of Fig. 1A, the shield member 20

is a baffle. The term baffle, as used herein, refers to a plate or screen that is for deflecting, directing or blocking a flow of a fluid.

The shield member 20 may comprise a mechanical support layer (not shown) on which the low permeability layer 22 is fixed. The mechanical support layer may be plate-shaped and may primarily be made of copper.

The shield member 20 is provided between the opening 40 of the shielding device 1 and the accommodating space 30. This means that it exerts a shielding effect at a location in-between the opening 40 and the accommodating space 30 and, in other words, between the opening 40 and the magnetically sensitive device 50 (when placed in the accommodating space 30). Therefore, the shield member 20 may prevent electromagnetic field flux and/or radiation from reaching the accommodating space 30 of the shielding device 1, i.e., from reaching the magnetically sensitive device 50. Thereby, the shield member 20 may shield off the electromagnetically sensitive device 50 located in the accommodating space 30 from electromagnetic noise.

According to Fig. 1A, the shield member 20 may comprise a high permeability layer 21 with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m). In particular, the high permeability layer 21 may be a metal-containing layer.

The shield member 20 may also comprise a low permeability layer 22 that is superconductive when cooled below a critical temperature. In particular, the low permeability layer 22 may be a superconducting layer.

According to Fig. 1A, the high permeability layer 21 may be provided between the opening 40 and the low permeability layer 22. Thus, electromagnetic field flux or radiation propagating towards the inside of the shielding device 10 may be diverted

away from a propagation direction towards the accommodation space by the high permeability layer 21. Any remaining electromagnetic field and/or radiation that gets past the metal-containing plate may be blocked by the low permeability layer 22.

Maintenance of the shielding device 10 or of a device placed therein may be carried out particularly conveniently and efficiently. As the shield member 20 may be taken out of the interior space 12, it may be possible to access the accommodating space 30 very easily.

According to Fig. 1A, the high permeability layer 21 and the low permeability layer 22 of the shielding device 1 of Fig. 1 may be separated by a gap. However, for other examples, the two the high permeability layer 21 and the low permeability layer 22 may be provided directly in contact, without a gap in-between.

Fig. 1B illustrates an embodiment wherein the high permeability layer 21 and the low permeability layer 22 are provided without a gap in-between. The other features are analogous as for the case of Fig. 1A.

The high permeability layer 21 and the low permeability layer 22 can be glued to each other or screwed together.

Alternatively, one or several other layers (e.g., one or several plates) may be provided in-between, and the shielding member 20 may, hence, comprise further layers/plates, etc. For example, a thermalization layer may be provided between the high permeability layer 21 and the low permeability layer 22. The thermalization layer may be made of copper.

Fig. 1C illustrates an embodiment wherein an intermediate layer 23 is provided in-between of the high permeability layer 21 and the low permeability layer 22. The intermediate layer 30

may be a thermalization layer. There may be several intermediate layers present. The intermediate layer may be in direct contact with the high permeability layer and the low permeability layer. The intermediate layer may also be distant from the high permeability layer and/or the low permeability layer.

The low permeability layer 22 (for example, a superconducting plate) and the high permeability layer 21 (for example, a metal-containing plate) may be provided with respective opening 24 through which a mechanical structure 60 and/or cable passes (see, e.g., Figs. 1A-1C). The mechanical structure 60 enables to connect the magnetically sensitive device 50 with another unit outside of the shielding device 1.

The openings 24 in the respective plates 21, 22 may also be used to let a supporting structure through the shield member 20. The supporting structure(s) may be used to support the shield member 20 (or shield members 20 when a plurality of shield members 20 is provided). In addition thereto or alternatively, the supporting structure(s) may be used to support a magnetically sensitive device 50 for stably supporting it in the accommodation space 30.

According to the embodiments of Figs. 1A, 1B, and 1C, the shield member 20 may be located well inside of the interior space 12 of the shielding device 1. Well inside in this context may be understood to mean distanced from the opening 40 of the shielding device 1, i.e., placed at a certain distance from it, so that it may not block the opening 40 of the shielding device 1. In an alternative, a shield member 20 may be located within the opening 40 of the shielding device 1. This means it will be located at a boundary of the interior space 12 (this would be adjacent to the upper ends of the side walls of the main shield body 10). In another alternative, a shield member 20 could also be located slightly outside of the interior space 12 of the shielding device 1.

The main shield body 10 of the shielding device 1 of Fig. 1D may comprise a high permeability layer 15 facing the inside, with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m). Namely, all the side walls and the bottom wall may comprise a high permeability layer 15 with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m). In a variant, part of the main body shield may also comprise a low permeability layer 16 (see the embodiment of Fig. 1E) that may be superconductive when cooled below a critical temperature. Part of the main body shield means some of the side walls and/or the bottom wall and even part of the side walls and/or part of the bottom wall comprise a low permeability layer 16.

In each of the embodiments of Figs. 1A-1D, the respective shield member 20 may comprise a mechanical support layer (not shown) on which the low permeability layer 22 is fixed. The mechanical support layer may be plate-shaped and may primarily be made of copper.

Fig. 2 illustrates how electromagnetic flux may flow into an embodiment of a shielding device 2 in accordance with the present disclosure.

The shielding device 2 of Fig. 2 comprises three shield members 200, 210, and 220 which may be baffles comprising a plurality of plates each. In fact, each of the three shield members 200, 210, and 220 comprises a high permeability layer 201, 211, and 221 and a low permeability layer 202, 212, and 222.

Electromagnetic noise (e.g. an electromagnetic flux) entering the shielding device 2) may be first guided away from the direction towards the accommodation space 30 through the high conductivity layer 201. It may in particular be guided laterally towards the side walls.

As a next layer when moving deeper inside the shielding device 2, the low permeability layer 202 of the first baffle prevents electromagnetic flux from passing through. A small gap between the side wall and the shield member 200 may contribute to a good shielding effect, as leaks along the side wall may be minimized.

A small part of electromagnetic noise may leak passed the first shield member 200, but will then encounter a second shield member 210. A large part of that remaining flux may be guided away from the direction towards the accommodation space 30 through the high conductivity layer 211. It may in particular be guided laterally towards the side walls. Subsequently, the low permeability layer 212 may prevent electromagnetic flux from passing through. A small gap between the side wall and the shield member 210 may contribute to a good shielding effect, as leaks along the side wall may be minimized.

A yet much small part of electromagnetic noise may leak passed the second shield member 210, but will then encounter a third shield member 220. A large part of that remaining flux may be guided away from the direction towards the accommodation space 30 through the high conductivity layer 221. It may in particular be guided laterally towards the side walls. Subsequently, the low permeability layer 222 may prevent electromagnetic flux from passing through. A small gap between the side wall and the shield member 220 may contribute to a good shielding effect, as leaks along the side wall may be minimized.

Fig. 3 shows a schematic view of a shielding device 2 in accordance with the present disclosure. The shielding device 2 is for shielding a device from electromagnetic noise. The shielding device 2 differs from the shielding devices 1 of Figs. 1A-1E in that it comprises a plurality of shield members 20 located within the shield body 10 of the shielding device

2. The reference numbers corresponding to the same components will therefore be kept.

Just as in the case of Figs. 1A-1E, also Fig. 3 shows a magnetically sensitive device 50 using dotted lines. This magnetically sensitive device 50 may, for example, be a quantum device, may be provided in the accommodating space 30, and may be shielded by the shielding device 2.

According to Fig. 3, a plurality of shield members 20 a,b,c may be located in the interior space. Figure 3 illustrates three shield members 20 located in the interior space. However, other total numbers of shield members 20 are foreseen as well. In particular, the total number of shield members 20 may be from 2 to 7, and in particular from 3 to 5. In particular, 3 to 5 shield members may be suited to keep the volumetric space small while providing very efficient shielding. A plurality of shield members (baffles) 20 can thus work together to reduce, in each iteration (for each baffle), the magnetic flux into the system so that the (QPU) performance is equivalent to a fully contained shield. There may be a maximum number of shield members (baffles), for example 4 - 5 baffles, as adding more baffles will have no further practical reduction (diminishing return).

The shield members 20a, 20b, and 20c may be structurally distinct from the main shield body 10. They may also be separable from the main shield body 10. They can be built in and out of the shielding device 1. That is, they may be removed from the interior space without being damaged and without damaging the main shield body 10.

All of the three shield members 20a, 20b, and 20c may be provided between the opening 40 and the accommodating space 30. They may exert shielding effects in-between and may thus prevent electromagnetic field flux and/or radiation from reaching the accommodating space. Thereby, the shield members

20 may shield off the quantum processing unit 50 (or a different quantum device provided in the accommodating space 30) from electromagnetic noise.

Each of the three shield members 20a, 20b, and 20c may comprise a high permeability layer 21 with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m). In particular, the high permeability layer 21 may be a metal-containing layer.

Each of the three shield members 20a, 20b, and 20c may also comprise a low permeability layer 22 that is superconductive when cooled below a critical temperature. In particular, the low permeability layer 22 may be a superconducting layer.

The shield members 20a, 20b, and 20c may be provided in series between the opening 40 and the accommodating space 30, as in the case of Fig. 2. Thus, electromagnetic fields and/or radiation may be prevented from approaching the accommodation space 30 very efficiently due to the alternating encounters with a diverting high permeability layer 21 (through which flow is diverted towards the sides and away from the direction towards the accommodation space 30) and a superconductive plate (that shields off and prevents noise from passing).

For each of the three shield members 30, their high permeability layer 21 may be provided between the opening 40 and their superconducting plate. Thus, electromagnetic field flux or radiation heading towards the inside of the shielding device 10 may be respectively diverted by the high permeability layer 21. What still gets past may be blocked by the superconductive plate. This may be successively repeated for what may still leak through. Three to five shield members may provide particularly good shielding effects, and the gain in shielding effect may be particularly high until reaching the total number of shield member of 3 to 5. The increase in shielding efficiency may merely be incremental when adding

further plates, so that saving costs and space may outweigh the benefit of additional shield members beyond a total of 3 to 5.

Maintenance of the shielding device 10 or of a quantum device placed therein (e.g., the quantum processing unit 50) may be carried out particularly conveniently and efficiently. As the shield members 20a, 20b, and 20c may be taken out of the interior space, it is possible to access the accommodating space 30 very easily.

As in Fig. 1, the high permeability layer 21 and the low permeability layer 22 of the shield members 20 a, 20b, and 20c of Fig. 3 are separated by a gap. In Fig. 3, each of the shield members 20a, 20b, and 20c comprise a gap separating the high permeability layer 21 and the low permeability layer 22. Furthermore, in Fig. 3, the gap is the same for each shield member 20a, 20b, 20c. In a variant, the gap between the high permeability layer 21 and the low permeability layer 22 can be different for each shield member 20a, 20b, and 20c. In a variant, the two layers may be provided directly in contact without a gap in-between. They can be glued to each other or screwed together. Alternatively, one or several other layers (e.g., one or several plates) may be provided in-between, and the shielding member 20a, 20b, and 20c may, hence, comprise further layers/plates, etc. For example, a thermalization layer may be provided between the high permeability layer 21 and the low permeability layer 22. The thermalization layer may be made of copper. Each of the shield member 20a, 20b, and 20c of the plurality of shield member may have a different design for the combination of the high and low permeability layers 21, 22.

Moreover, adjacent shield members 20a, 20b, and 20c may also be separated by respective gaps d. The gaps d may all be the same or they may differ. The gaps d between the adjacent shield members 20a, 20b, and 20c may be larger than the gaps d between

the high and low permeability layers 21, 22 of each shield member 20a, b, c.

Each of the high permeability layer 21 and the low permeability layer 22 of each of the three shield members 20a, 20b, and 20c are provided with an opening through which a cable 60 passes. It connects the quantum processing unit 50 (or another quantum device) with another unit outside of the shielding device 1. The openings in the plates can also be used to let a supporting structure penetrate.

The three shield members 20a, 20b, and 20c may all be structurally the same or two may be the same and one may differ from two of them. Alternatively, they may all three be structurally different from one another, e.g., in terms of thickness and/or material composition and/or layers, distribution of materials, etc.

In particular, the high permeability layer 21 of each of the three shield members 20a, 20b, and 20c may have a relative electromagnetic permeability which is comprised in a range of $1.5 \cdot 10^5$ to $2.5 \cdot 10^5$ Henries. However, different ranges (in accordance with what is disclosed above) may be possible. Moreover, all three shield members 20a, 20b, and 20c may in this regard be the same, or they can mutually differ.

The three shield members 20a, 20b, and 20c may each comprise a mechanical support layer (not shown) on which the low permeability layer 22 is fixed. The mechanical support layer may be plate-shaped and may primarily be made of copper.

The top shield member 20a in Fig. 3 may be the outermost shield member 20a, whereas the bottom shield member 20c in Fig. 2 may be the innermost shield member 20c.

The main shield body 10 of the shielding device 2 of Fig. 3 may comprise a high permeability layer with a relative

electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a low permeability layer that may be superconductive when cooled below a critical temperature.

The shielding device 2 of Fig. 3 together with the magnetically sensitive device 50 provided therein is an example of a shielded quantum processing unit in accordance with the present disclosure.

Fig. 4A shows a schematic perspective view of an embodiment of a shielding assembly 100 in accordance with the present disclosure.

The shielding assembly 100 may comprise five shielding devices 1a, 1b, 1c, 1d, and 1e including components analogous to those described above in the context of Figs. 1A through 3. The five shielding devices 1a, 1b, 1c, 1d, and 1e may be inserted into one another, from an outermost shielding device 1a (the top one in Fig. 4A) to an innermost shielding device 1e (the bottom one in Fig. 4A), to form the shielding assembly 100. The three innermost shielding devices 1c, 1d, and 1e comprise a respective main shield body with a superconductive layer. The latter is located at least partially on the inside wall of the main shield body. However, in the case of other embodiments, any one or several of a plurality of shield devices may comprise a main shield body including a superconductive layer.

Just as in the case of Figs. 1A through 3, the shield members 20 may all be provided in the form of plates and in parallel to the respective opening 40 (at the top of the main shield body 10). In particular, the shield members 20 are also parallel to the bottom wall of the main shield body 10.

The shielding devices of Figs. 1A through 3 and the shielding assembly 100 of Fig. 4A together with the respective magnetically sensitive device 50 are examples of shielded magnetically sensitive devices (such as, e.g., shielded

quantum processing units) in accordance with this disclosure. An example of a quantum computer in accordance with the present disclosure is a computer comprising a shielded quantum processing unit.

Fig. 4B depicts a sectional view of the embodiment of the shielding assembly 100 of Fig. 4A. It depicts how five shielding devices 1A, 1B, 1C, 1D, and 1E are inserted into one another.

Fig. 4C depicts a schematic sectional view of an embodiment of a shielding device 100 in accordance with the present disclosure, where two shielding devices 1B, 1C according to the disclosure are positioned side by side within a shielding device 1A. In the case of Fig. 4C, the shielding device 1A comprises a lid, whereas the shielding devices 1B and 1C do not. However, in other variants, any one or several of (e.g., all of) the shielding devices could be provided with or without a lid. In the case of Fig. 4C, the main shield body 20 of the shielding device 1B comprises a superconductive layer. The latter is located at least partially on the inside wall of the main shield body. However, in the case of other embodiments, any one or several of a plurality of shield devices may comprise a main shield body including a superconductive layer.

Each of the shielding devices 1B, 1C actually houses a different magnetically sensitive device 50 inside. For example, the shielding device 1B may comprise a TWPA, and the shielding device 1C may comprise another quantum device, for example, a quantum processing unit. In a variant, one or several (or all) of a plurality of shielding devices 1 may also comprise the same type of magnetically sensitive device 50.

The shielding devices 1B and 1C each comprise a mechanical structure 60 which is not centrally located with respect to the main body shield 1 and which connects the respective

sensitive magnetic device 50. The mechanical structure 60 also comprises an opening to let a cable pass through to the sensitive magnetic device 50.

Fig. 5A depicts an embodiment of a shielding assembly 200 in accordance with the present disclosure. The shielding assembly 200 comprises a shielding device 4 provided inside of an additional outer main shield body 70. The shielding device 200 of Fig. 5A comprises a first shield member 20a with a first high conductivity layer 21a and a first low conductivity layer 22a, a second shield member 20b with a second high conductivity layer 21b and a second low conductivity layer 22b, and a third shield member 20c with a third high conductivity layer 21c and a third low conductivity layer 22c. The shielding device 4 also comprises a superconducting material layer 22 on a portion of the side walls of its main shield body. The portion of the side walls or inner walls comprising the superconducting layer 22 is actually located below the portion where the shield members 20a, 20b, 20c are located. In this embodiment, a lid is also present below the bottom shield member 20c, separating the portion of the inner walls where the shield members 20a, 20b and 20c face the inner walls from the portion of the inner walls where the superconducting material layer 22 is provided on the inner walls. The superconducting material layer 22 is also provided on the bottom wall. Fig. 5B depicts experimental results concerning the shielding effect achieved at different locations surrounding and inside the shielding assembly 200 in accordance with the present disclosure.

The shielding device 4 of the shielding assembly 200 for which the shielding of noise in terms of electromagnetic fields and radiation was experimentally tested, comprises three shield members. The shading in the different parts inside of the shield member show that the shielding effect becomes stronger and stronger inside of the shielding device.

Fig. 6 is a graph that shows experimental results concerning the shielding effect achieved at different locations surrounding and inside the shielding assembly 200 to which also the results of Fig. 5B relate to.

The measured magnetic flux density (measured in Tesla) on the y-axis is shown in function of the z-coordinate on the x-axis, wherein the z-direction is the height direction of the shielding device. In other words, the z-coordinate extends from the bottom to the top, i.e., from the bottom side of the shielding device to the accommodation space, past the shield members and towards the opening of the shielding device.

Looking at Figs. 5A and 5B, one can see that the opening of the shielding assembly 200 is associated with a z-coordinate of around 18 and is covered by a lid 11. The shield members are then associated with z-coordinates around 17, 15, 13, and 11. The flux density decreases significantly when moving from the z-range of around 18 to around 10 in Fig. 5B. Fig. 5B shows all components (x, y, and z components) of the flux density (as a vector quantity) at a particular z-coordinate range, as well as the norm (i.e., an absolute value of the strength).

In Fig. 5C, the shielding device extends from around $z=-3$ to $z=18$, as a comparison to Fig. 5B reveals. At around $z=0$, a device, in particular a quantum device such as a quantum processing unit, is positioned, as shown in Fig. 5C by the dotted vertical line. Fig. 5C shows extremely good shielding against the magnetic flux. The magnetic flux density norm takes on values around 10^{-12} T where the device is placed. It is around 7 orders of magnitude lower than outside of the shielding assembly 200. This enables the quantum device to operate in an environment with minimal electromagnetic field interference.

It will be apparent to those skilled in the art that various modifications and variations can be made in the disclosed

devices and systems without departing from the scope of the disclosure. Other aspects of the disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the features disclosed herein. It is intended that the specification and examples be considered as exemplary only. Many additional variations and modifications are possible and are understood to fall within the framework of the disclosure.

Claims

1. A shielding device for shielding a magnetically sensitive device, in particular a quantum device, from electromagnetic noise, the shielding device (1) comprising
a main shield body (10) that partially encapsulates an interior space (12) and is provided with an opening (40) that provides access to the interior space (12), with a part of the interior space (12) being an accommodating space (30) for accommodating a magnetically sensitive device (50), in particular a quantum device; and
at least one shield member (20) that is located in the interior space (12) and between the opening (40) and the accommodating space (30), and that is structurally distinct and/or separable from the main shield body (10);
wherein the shield member (20) comprises at least a high permeability layer (21) with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a low permeability layer (22) that is a superconductive material layer that is superconductive when cooled below a critical temperature, and
the high permeability layer (21) is provided between the opening (40) and the low permeability layer (22).
2. The shielding device of claim 1, comprising a plurality of shield members (20) located in the interior space (12) and between the opening (40) and the accommodating space (30),
wherein, two or more, optionally all, of the plurality of shield members (20) comprise a respective high permeability layer (21) with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a respective superconductive material layer (22) that is superconductive when cooled below a

critical temperature, and

the respective high permeability layer (21) is provided between the opening (40) and the respective superconductive material layer (22) of the respective shield member (20).

3. The shielding device of claim 1 or 2, where the high permeability layer (21) and the superconductive material layer (22) are separated by a gap.
4. The shielding device of any one of claim 1 to 3, wherein at least two shield members (20) of the plurality of shield members (20) differ structurally, optionally, in terms of the high permeability layer (21) and the superconductive material layer (22) of the shield member (20).
5. The shielding device of any one of claim 1 to 3, wherein at least two shield members (20) of the plurality of shield members (20) are structurally the same, wherein, optionally, several or all of the plurality of shield members (20) are structurally the same.
6. The shielding device of any one of the preceding claims, wherein the relative electromagnetic permeability of the high permeability layer (21) of the at least one shield member (20) and/or of any one or several, or optionally all, of the plurality of shield members (20) is in a range of $1.5 \cdot 10^5$ to $2.5 \cdot 10^5$ Henries, optionally in the range of $1.8 \cdot 10^5$ to $2.2 \cdot 10^5$ Henries.
7. The shielding device of any one of claims 2-6, wherein the plurality of shield members (20) consists of from 2 to 7 shield members (20), optionally from 3 to 5 shield members (20).
8. The shielding device of any one of claims 2-7, wherein a

distance between adjacent shield members (20) is in a range of 3 times, or less, a diameter of at least one opening provided for letting a structure such as a cable or a stabilizing member pass through, optionally twice the diameter or less, or equal to the diameter or less.

9. The shielding device of any one of claims 1-8, wherein a thickness of the high permeability layer (21) of the at least one shield member (20) and/or of any one or several, or optionally all, of the plurality of shield members (20) is in a range of from 0.2 mm to 3 mm, optionally from 0.2 mm to 1.5 mm or from 0.7 mm to 1.3 mm or from 0.8 mm to 1.2 mm, and/or

wherein a thickness of the superconductive material layer (22) of the at least one shield member and/or of any one or several, or optionally all, of the plurality of shield members (20) is in a range of from 0.2 mm to 3 mm, optionally from 0.2 mm to 1.5 mm or from 0.7 mm to 1.3 mm or from 0.8 mm to 1.2 mm.

10. The shielding device of any one of the preceding claims, wherein the at least one shield member (20) and/or of any one or several, or optionally all, of the plurality of shield members (20) comprise an additional layer (23), in particular a mechanical support layer, the additional layer (23) is provided between the high permeability layer (21) and the superconductive material layer (22), and the additional layer (23) optionally comprises copper.

11. The shielding device of any one of the preceding claims, wherein a surface of the high permeability layer (21) of the at least one shield member (20) and/or of any one or several, or optionally all, of the plurality of shield members (20) is oriented towards the opening (40), wherein the high permeability layer (21) is optionally parallel to the opening (40); and/or

wherein a surface of the superconductive material

layer (22) of the at least one shield member (20) and/or of any one or several, or optionally all, of the plurality of shield members (20) is oriented towards the opening, wherein the superconductive material layer (22) is optionally parallel to the opening (40).

12. The shielding device of any one of the preceding claims, comprising an outermost shield member (20) comprising at least an outermost high permeability layer (21) with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and an outermost superconductive material layer (22) that is superconductive when cooled below a critical temperature.
13. The shielding device of claim 12, wherein the outermost high permeability layer (21) is located at a boundary of the interior space (12) or outside of the interior space (12), wherein the outermost high permeability layer (21) optionally at least partially closes the opening (40).
14. The shielding device of any one of the preceding claims, wherein a clearance range is provided between the at least one shield member (20) or any one of, several, or optionally all of the plurality of shield members (20) and the main shield body (10), respectively, and the clearance gap has a width in a range of up to 3 mm, optionally up to 1.5 mm.
15. The shielding device of any one of the preceding claims, wherein the at least one shield member (20) and/or of any one or several, or optionally all, of the plurality of shield members (20) comprises at least one opening (40) to allow for a supporting structure (60) and/or a cable to pass through the at least one shield member (20), or any one or several, or all, of the plurality of shield members (20).

16. The shielding device of any one of the preceding claims, wherein the at least one shield member (20) comprises a metal-containing plate (21) and a superconductive plate (22),

Wherein the metal-containing plate (21) of the at least one shield member comprises, optionally consists of, the high permeability layer (21), and the superconductive plate of the at least one shield member (20) comprises, optionally consists of, the superconductive material layer (22).

17. The shielding device of any one of the preceding claims, wherein any one or several, optionally all, of the plurality of shield members (20) comprise a respective metal-containing plate and a respective superconductive plate,

wherein, for any one or several, optionally all, of the plurality of shield members (20), the respective metal-containing plate comprises, optionally consists of, the high permeability layer (21) and the respective superconductive plate comprises, optionally consists of, the superconductive material layer.

18. The shielding device of any one of the preceding claims, wherein the superconductive layer of the at least one shield member (20) and/or of any one or several, or optionally all, of the plurality of shield members (20) comprises any one or more than one of the materials selected from the list consisting of: Al, Ti, Nb, and Sn.

19. The shielding device of any one of the preceding claims, wherein the high permeability layer (21) of the at least one shield member (20) and/or of any one or several, or optionally all, of the plurality of shield members (20) comprises any one or more than one of the materials selected from the list consisting of: Cryophy, Cryperm, A4K, Tokin R, other cryogenic compatible high

permeability materials, typical of hi Ni-iron alloys.

20. The shielding device of any one of the preceding claims, wherein the main shield body (10) comprises at least one of a high permeability layer (21) with a relative electromagnetic permeability of at least 10^5 Henries per meter (H/m) and a superconductive material layer (22) that is superconductive when cooled below a critical temperature.
21. The shielding device of any one of the preceding claims, wherein the main shield body (10) comprises side walls and a bottom wall and the opening (40) is provided on an end of the shielding device (1) that is distant to the bottom wall, wherein .

wherein a superconductive material layer, optionally a superconductive layer, is provided on at least one of the inside walls of the side walls and/or bottom wall of the main shield body (10) that is exposed to the interior space (12) on at least a part of the inside wall, optionally on the entire inside wall.
22. The shielding device of claim 21, wherein the superconductive material layer provided on at least one of the inside walls of the side walls and/or bottom wall of the main shield body (10) is provided in at least a part of the accommodating space (30), and

wherein there is no superconductive material layer provided on at least a part of the inside walls of the main shield body (10) that face the at least one of, several, or all of the plurality of, the shield members (20).
23. A shielding assembly comprising a plurality of shielding devices (1) according to any one of the preceding claims, wherein the plurality of shielding devices (1) are at least partially inserted into one another, from an

outermost shielding device to an innermost shielding device.

24. The shielding assembly of claim 23, wherein the outermost shielding device is provided with a lid member configured to close off an opening (40) of the outermost shielding device, said lid member comprising at least one lid member opening for letting a component, such as a cable or a stabilizing structure, pass.
25. The shielding assembly of claim 23 or 24, wherein at least one inner shielding device comprises an inner lid member configured to close off an opening (40) of the inner shielding device, said inner lid member comprising at least one inner lid member opening for letting a component, such as a cable or a stabilizing structure, pass.
26. A shielded quantum processing unit comprising the shielding device (1) according to any one of claims 1-22 or the shielding assembly according to any one of claims 23 to 25 and a quantum processing unit provided in the accommodation space (30).
27. A quantum apparatus comprising the shielding device (1) according to any one of claims 1-22 and/or the shielding assembly of any one of claims 23 to 25.
28. The quantum apparatus according to claim 27, wherein the quantum apparatus is a quantum computer.