Subject: Re: Are the field lines the trajectory of a particle with mass M?
Posted by James Kuyper on Sun, 14 Mar 2004 16:01:51 GMT
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pakachunka wrote:
>
> I believe the field lines are not the trajectories... but a friend of
> mine is driving me crazy, because he says they are.
>
> How can I demonstrate that field lines are not the trajectories?
>
> I mean: what are field lines, to start?

Your question is too broad. There are many kinds of fields. Field lines are associated with vector fields. A typical vector field may be described by a vector-valued function v(x,y,z,t), which means it has a single size and direction for every meaningful combination of x,y,z, and t. Field lines are lines associated with a vector field that are arranged so that at every point, the tangent to the line at that point is in the same direction as the vector field at that point. In other words, the vector field tells the lines where to go.

Now, if the two of your are talking about the velocity field of a fluid, then the field lines are indeed exactly the trajectories of the individual particles that make up the fluid.

However, fluid dynamics is fairly complicated, and your question gives the impression that you're at a fairly elementary level in physics. In that case, the fields you're most likely to run into aren't velocity fields, but electrical or gravitational fields. For example, the electrical field in the vicinity of a particle with charge Q, at a position <x0,y0,z0> has an associated static electrical field at a point <x,y,z> which is given by

E(x,y,z) = kQ<x-x0,y-y0,z-z0>/r^2

where r^2=(x-x0)^2+(y-y0)^2+(z-z0)^2.

The important thing is that the electrical field is NOT a velocity field, and therefore the field lines are not in general the same as the particle trajectories. If the electrical field provides the only force that is acting on a particle with a charge of q and a mass of m, then it will feel an acceleration of Eq/m. Acceleration is not velocity, it's the first derivative of the velocity. There's a connection between the electrical field lines and the trajectories of the particals, but it's not a simple one.

Subject: Re: Are the field lines the trajectory of a particle with mass M?
Posted by R.G. Stockwell on Sun, 14 Mar 2004 17:40:03 GMT
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"pakachunka" <pakachunka@yahoo.com> wrote in message
news:d6fc922e.0403131602.8ec07b2@posting.google.com...
> I believe the field lines are not the trajectories... but a friend of
> mine is driving me crazy, because he says they are.
>
> How can I demonstrate that field lines are not the trajectories?
>
> I mean: what are field lines, to start?

Following James' anwer, if it is gravity or electric _force_ field,
simply swing a cat on the end of a rope, and point out that at no
time is the force (tension along string ignoring gravity etc) lined
up with the trajectory. ie the "force field line" is always towards the
center of the circle.

cheers,
bob

PS since this is an IDL group, I'd write a program to solve
the equations for circular motion, and draw the velocity vector and
force vector and many discrete points, and perhaps animate it.

Subject: Re: Are the field lines the trajectory of a particle with mass M?
Posted by jeyadev on Mon, 15 Mar 2004 22:04:33 GMT
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In article <405481EF.6359E0DA@saicmodis.com>,
James Kuyper <kuyper@saicmodis.com> wrote:
> pakachunka wrote:
>>
>> I believe the field lines are not the trajectories... but a friend of
>> mine is driving me crazy, because he says they are.
>>
>> How can I demonstrate that field lines are not the trajectories?
>>
>> I mean: what are field lines, to start?
>
> Your question is too broad. There are many kinds of fields. Field lines

Agreed, ...

> are associated with vector fields. A typical vector field may be
> described by a vector-valued function v(x,y,z,t), which means it has a

> single size and direction for every meaningful combination of x,y,z, and
> t. Field lines are lines associated with a vector field that are
> arranged so that at every point, the tangent to the line at that point
> is in the same direction as the vector field at that point. In other

... but this is a concise answer to the broad question.

> words, the vector field tells the lines where to go.
>
> Now, if the two of your are talking about the velocity field of a fluid,
> then the field lines are indeed exactly the trajectories of the
> individual particles that make up the fluid.

Here, things get complicated. I would suggest a quick read of the first couple of pages of Chap. 3, 'An Introduction to Fluid Dynamics' by G. K. Batchelor. There are three kinds of lines you need to worry about.

1. Streamline: A line whose tangent is everywhere parallel to the velocity vector field v(x,y,z,t) instantaneously. Here, v(x,y,z,t) is just the velocity of the fluid at point (x,y,z) at time t.

2. The Path Line (or simply Path): This is just the path traced by a particular element of the fluid. It conincides with the streamline only when the flow is steady (i.e. the velocity field v does not depend on time).

3. The Streak Line: The line along which lie all those fluid elements that earlier passed through a certain point in space. This is the line seen when one injects smoke into a gas or a dye into a liquid to get a feel of the 'motion' of the liquid.

> However, fluid dynamics is fairly complicated, and your question gives

Yes! And so, only in the case of the steady state flow do the three kinds of lines coincide. Thus the velocity field 'lines' are NOT, in general, "the trajectories of the individual particles that make up the fluid".

> the impression that you're at a fairly elementary level in physics. In
> that case, the fields you're most likely to run into aren't velocity
> fields, but electrical or gravitational fields. For example, the
> electrical field in the vicinity of a particle with charge Q, at a
> position <x0,y0,z0> has an associated static electrical field at a point
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> field, and therefore the field lines are not in general the same as the
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> will feel an acceleration of Eq/m. Acceleration is not velocity, it's
> the first derivative of the velocity. There's a connection between the
> electrical field lines and the trajectories of the particals, but it's
> not a simple one.

Paths of charged particles in certain specail configurations of electric and magentic fields are rather well studied and an undergraduate text in Classical Mechanincs (e.g. Symon or Marion) as well as books on Classical Electrodyanmics should have some coverage. These problems are much more fun when relativity comes in :-)

--

Surendar Jeyadev jeyadev@wrc.xerox.bounceback.com

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Subject: Re: Are the field lines the trajectory of a particle with mass M?
Posted by James Kuyper on Mon, 15 Mar 2004 22:45:17 GMT
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Surendar Jeyadev wrote:
>
> In article <405481EF.6359E0DA@saicmodis.com>,
> James Kuyper <kuyper@saicmodis.com> wrote:
...
> G. K. Batchelor. There are three kinds of lines you need to worry about.
>
> 1. Streamline: A line whose tangent is everywhere parallel to the
...
> 2. The Path Line (or simply Path): This is just the path traced by a
...
> 3. The Streak Line: The line along which lie all those fluid elements

I should have specified that I was talking about steady-state fluid flow. I was trying to point out one case where field-line and trajectory were the same thing, before explaining why that's not true in general.

...
> Electrodyanmics should have some coverage. These problems are much more
> fun when relativity comes in :-)

Especially when you throw in general relativity in strong gravitational
and electrical fields. :-) Geons are a particularly extreme example: a
ball made up entirely of photons which are moving in circles because,
and only because, of their mutual gravitational attraction.

Subject: Re: Are the field lines the trajectory of a particle with mass M?
Posted by profxtjb on Tue, 16 Mar 2004 04:40:20 GMT
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James Kuyper <kuyper@saicmodis.com> wrote in message
news:<405631FD.7D979D71@saicmodis.com>...

I know a little bit about the 'kugelblitz,' about geons, and about
self-gravitating quantum systems of various kinds. If you do want to
think of photons moving about it is helpful to realize that the
electromagnetic fields are orthogonal to the direction of propagation.

> Especially when you throw in general relativity in strong gravitational
> and electrical fields. :-) Geons are a particularly extreme example: a
> ball made up entirely of photons

The kugleblitz or, in English, the sphere of light.
