Computational Electromagnetic and Applications
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Lecture No 35
Finite Volume Time Domain Method-III

So we have covered quite a bit in the case of finite volume time domain. So we have looked into the basic formulation starting from the computational fluid dynamics prospective we have given certain justifications as on why it is working what is the formulation in terms of Physics in terms of hyperbolic formulation and what are the eigenvectors and eigenvalues and also we have given certain solid Foundation on how to model this for 3D problem or a 2D problem and later on we also discussed on the domain truncations you have discussed quite advanced techniques starting from the Benergen PML To also applications using universal PML and in the applications we have shown quite interesting problems starting from simple waveguide truncation 2 horn antenna 2 more more complicated really complicated problem which is even for commercial solvers a big challenge . So that being said the problem comes to one simple question.

So finite volume time domain method is a very very unique method it has certain advantages compared to finite element method because we don't need to do a matrix in version if you are working in a frequency domain you normally end up in doing Matrix inversion and also time domain problems it's very difficult because sometimes formulation of finite element method is implicit . So still you will come inevitably to a mattress in version issue with that being said the finite volume time domain method avoids all this kind of complication and it has certain beauty but there is something hidden here the hidden thing is it has certain limitations and his limitations are not openly discussed in public literatures we wanted to make sure that when you understand the method you also understand the limitations of the method where it is useful where it is not useful.

So we will in this particular module discuss on the limitations of the method both from the numerical accuracy point of you and also from the computational cost point of you and also we will discuss why it is that way how we can go forward what are the future areas of research that is going on and also give certain directions for for the research so that being said that start with the challenges.

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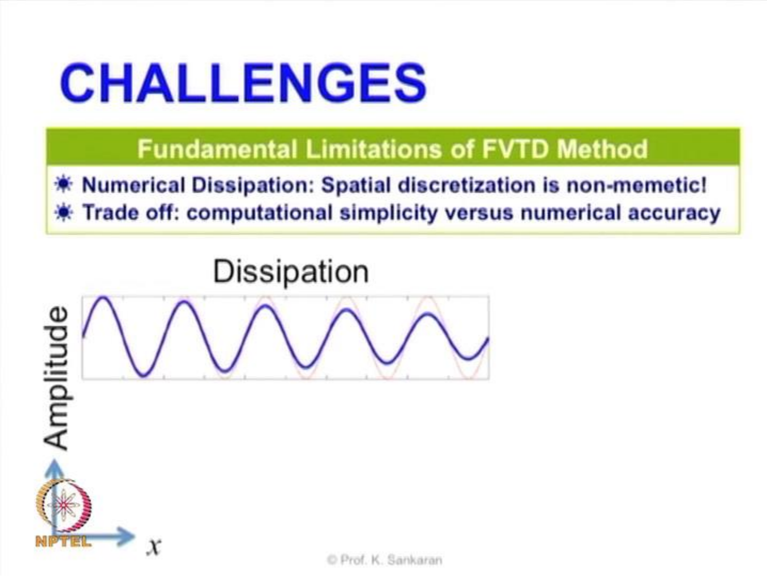

We said that the method is having numerical dissipation so what I mean by that is when you are talking about a simple waveguide problem where you are talking about wave propagation you see that along the x-axis amplitude of a wave where Z the exact value you is an America Lee computed value you will see that the amplitude decreases over period of time so that is the numerical dissipation what you're talking about in other words numerical error related to the amplitude.

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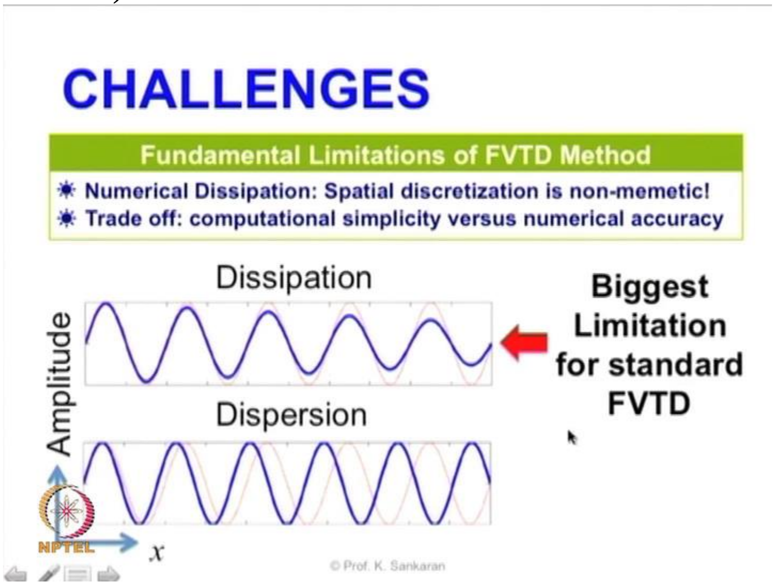

the other one is you will also have dispersion where the amplitude might not be affected by the propagation velocity of the Waves is not actually me mimicking or replicating the exact value so you will see that there is a difference in the wave velocity here or the propagation speed is different for different things for the exact solution versus a numerical solution in the case of finite volume the biggest challenge is the numerical dissipation of course here exaggerated the numerical dispersion in a way to showcase the meaning of dispersion here in the case of finite volume we have dispersion we definitely have dispersion but this dispersion is not as exaggerate as it is shown here just for the example what we are shown here the dispersion value for finite volume time domain what we have constraints or within the limitations of numerical accuracy what we need but this one the numerical dissipation or in other words amplitude BK for a period of wavelengths is something that is a biggest imitation of the standard finite volume method when I say standard finite volume method I am talking about values of the a field and H field Store in only one particular location

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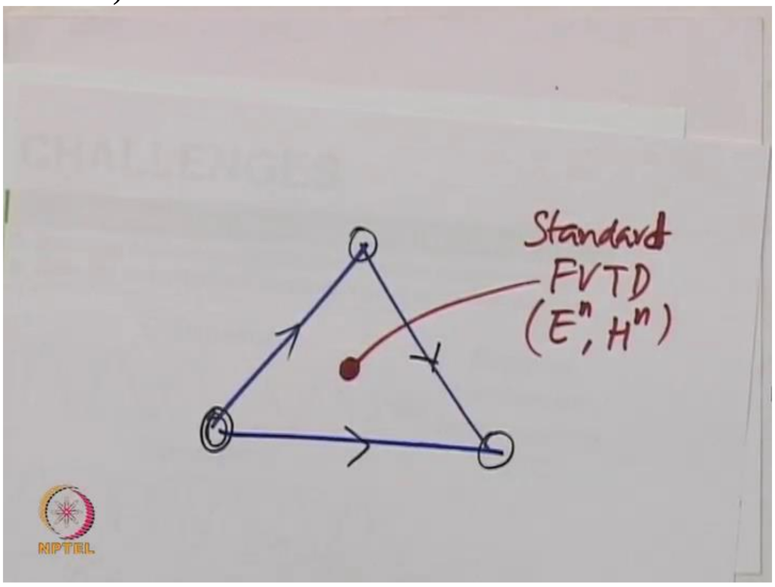

in other words as we remember we have a triangle now represented like this in the case of finite element you have you might have values that are stored in the nodal values are you can have values also stored in theedges so then it will be called as as element or another element but in the case of finite volume the values are stored only in the centre so standard FB TD the E field at N and the H field at N they are all stored in the centre so this has certain advantage because numerically it’s less heavy compared to the finite element method and also we are able to compute the value of e and H field at one point in time and one point in space so in other words it helps you to P more accurate instead of staggering in space or time you don’t need to do that but it has disadvantages of dissipation so that is aspect of dissipation there is someone who is starting to work on finite volume time domain should be aware of.

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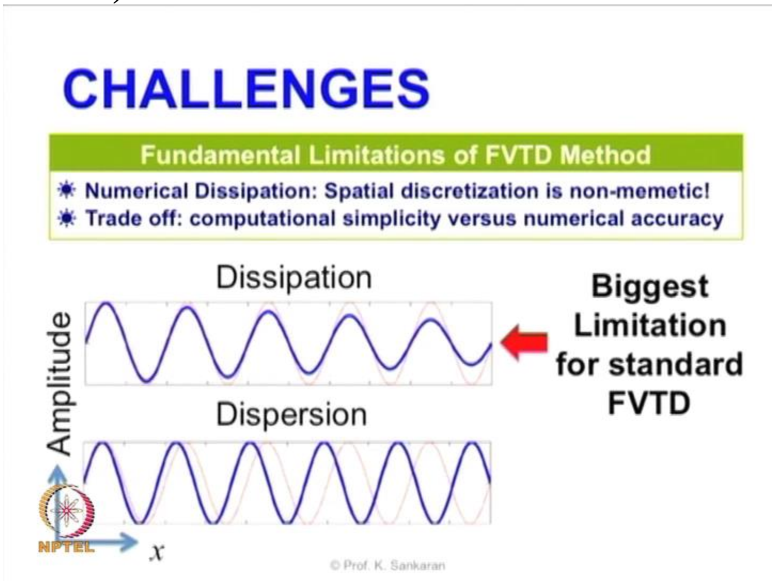

If you are not aware of that for some problems you might end up in difficulty in getting the right accuracy you want one way to solve this is you go from Lambda equal to 10 to Lambda equal to 20 or 30 but this again has this trade off for computational cost versus accuracy so this is something that as a numerical scientist who is working in computational problem you have to make a better informed decisions on what is good and what is not good for your particular problem and that being said what are the ways in which this can be understood is.

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since E and H field are co-located the co locating itself doesn't follow the duality what I mean by duality will become clear in our next module on algebraic topology and other steps for now you can understand E field and H field have different topological characterization that is something will be destroyed in the case when you make them co locate in space and time when you associate them both to a particular point you are inherently killing the dual nature of E and H field and also the topological connection of E and H field and the second thing is in the case of finite volume method .

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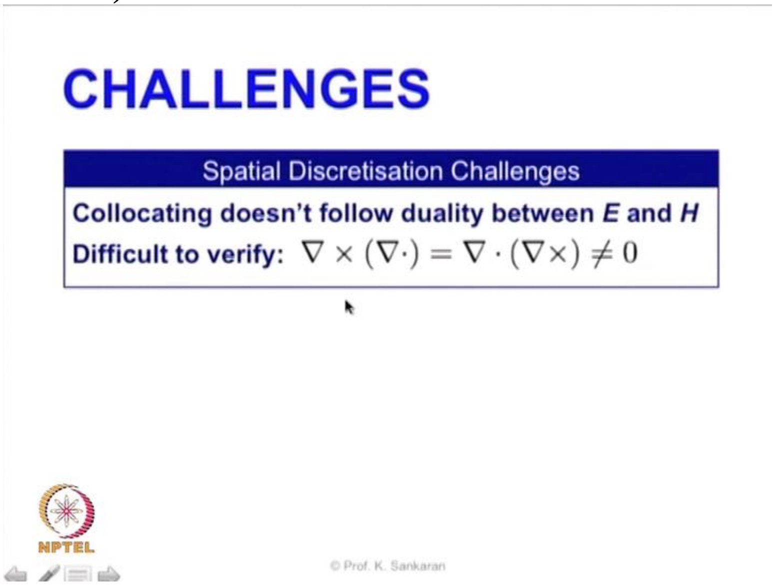

Although you don't see the difficulty that the Curl of the divergence are the divergence of the curl it should be equal to zero this is difficult to verify because there is so much dissipation is going on this particular condition even if it is not equal to zero will not be a huge problem but still is one of the things that we need to understand because a special discretisation doesn't have the duality nature and also it is very difficult to verify this one.

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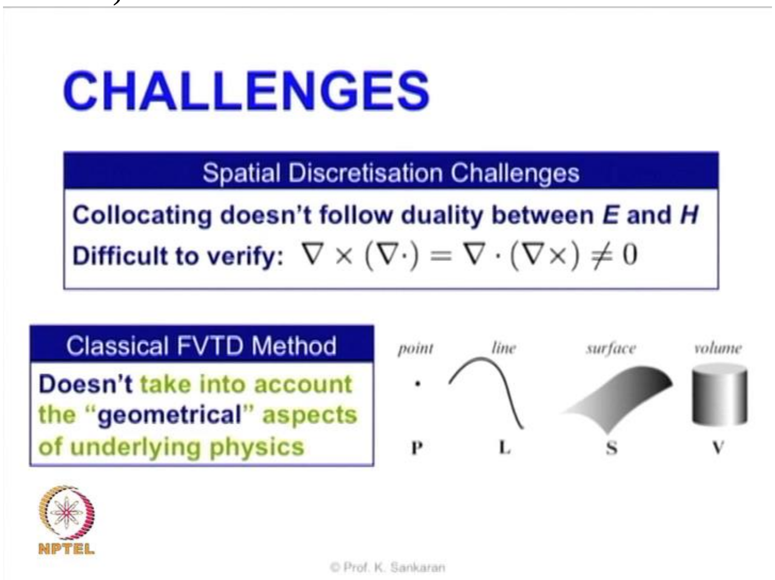

As I already told there are certain geometrical Association of vectors whether it's a field or H field the vectors are associated with line some of the vectors are associated with surface for example a field is always associated with a line but in the case of finite volume method we are associating E and H field to a point there are values stored in the. But there is an association between in SQL to the line which we are not taking into account again the value of the fluxes are associated two surfaces this is something that we will see in the next models but still what I wanted to do here is I wanted to give you a direction in which we are going to go in the next module which will take in the account the inherent Waller to between the electric field and the magnetic field not only that it will also use the topological objects we are interested in making sure that the field quantities are associated with those topological objects the topological objects could be a. Could be a line could be a surface or could be a volume so this is what we will be doing in the next series of lectures before we finish off with this module what I wanted to give us some additional material.

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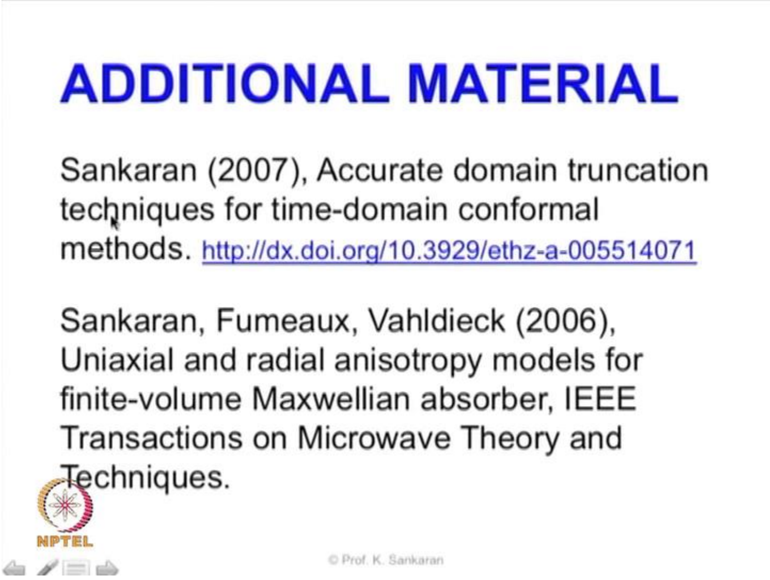

So this is my PhD thesis which is also available online using this link or you can just Google search this particular topic it basically discusses all the topics and all the equations and all the things that we have discussed in this module so it is the accurate domain truncation techniques for time domain conformal methods the most important method we will be focusing here is the finite volume time domain method it's equally applicable for higher order methods like discontinuous Galerkin or higher order finite element methods and also one another paper that is interesting to see is the uniaxial radial anisotropic models for finite volume Maxwell in absorber it's also available the IEEE transactions if you are interested in open access I think this particular thesis will give you all the things what we have discussed so with this we can come to a stop we have covered pretty much entire to set off finite volume time domain method and we will focus on other methods understanding the limitations we will take it to next methods how those methods can help us resolving those issues what we have with finite volume time domain method with this I would like to conclude this particular module thank you!