A new model for **nulling** and **moding** in radio pulsars

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(And More)

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2022.4

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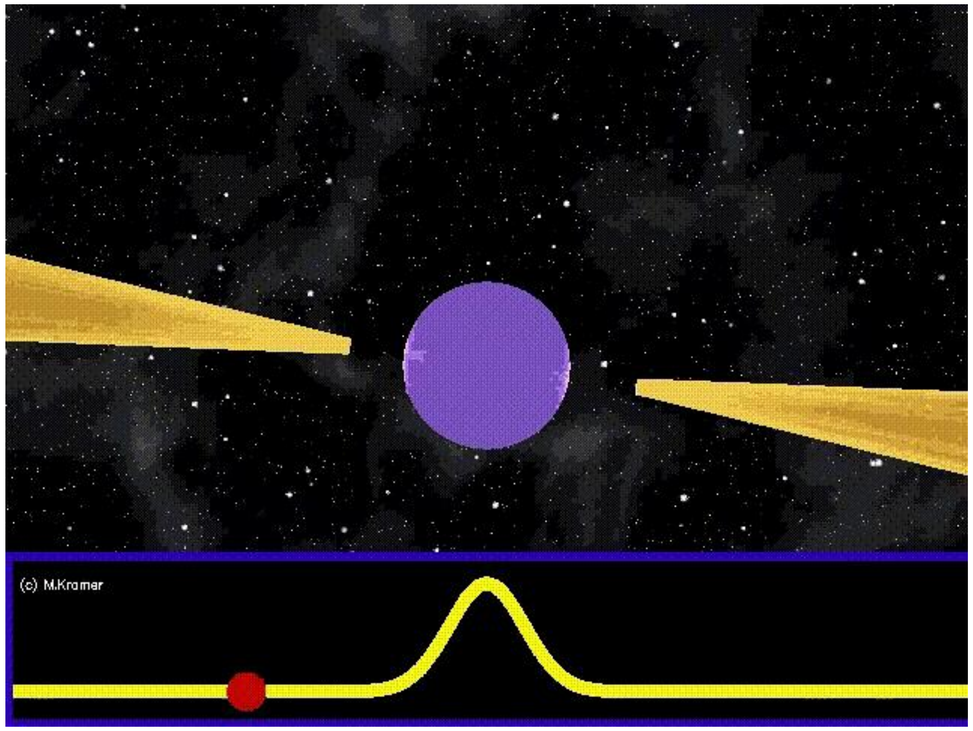
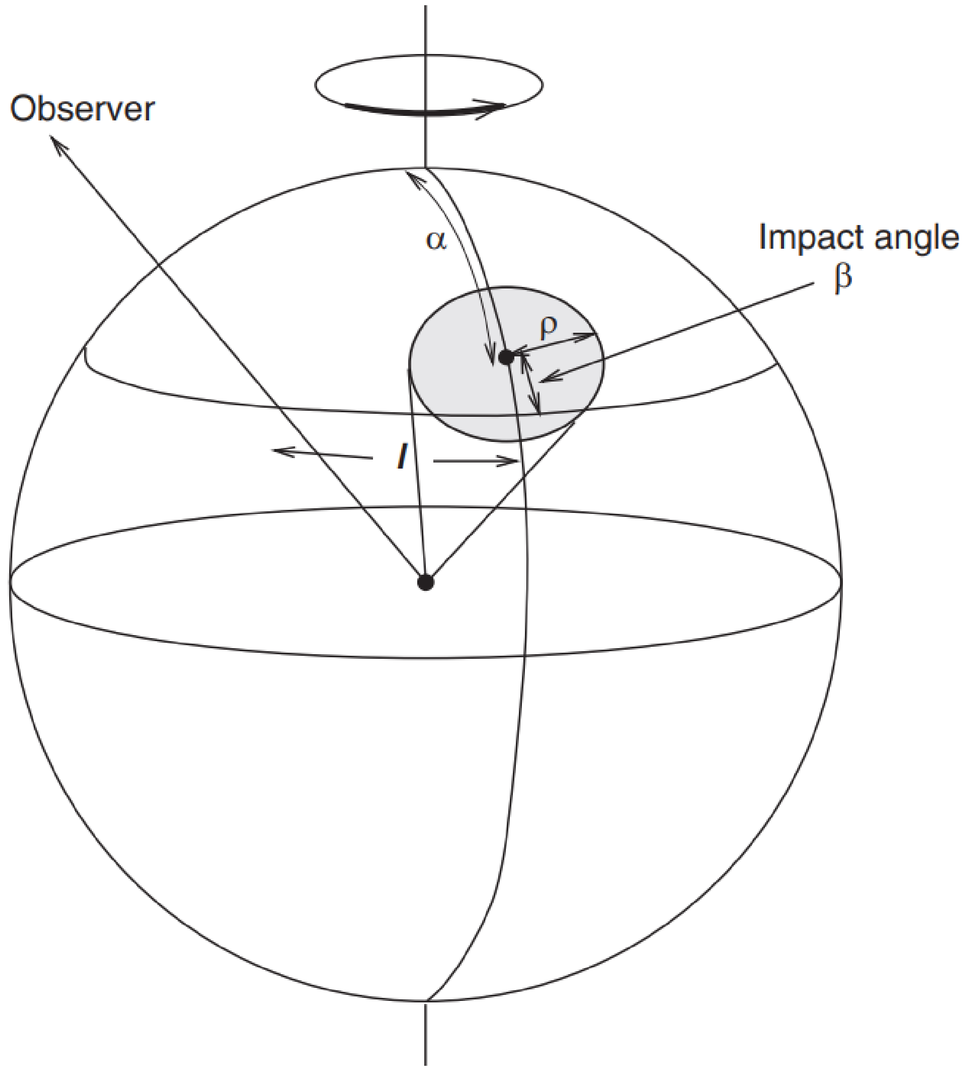
I. Introduction

Radio pulsar: basic geometry

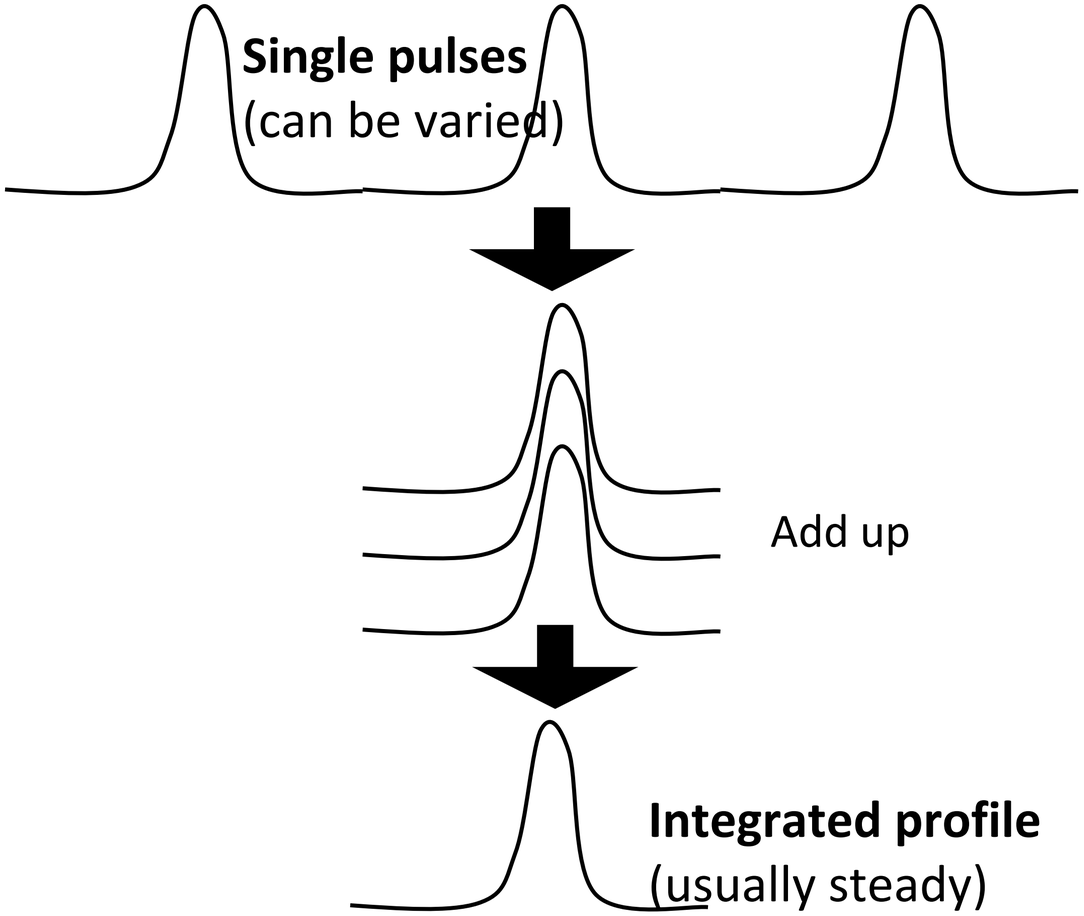


Credit: M. Kramer



From *Pulsar Astronomy*

Integrated profile, single pulses and sub-pulses



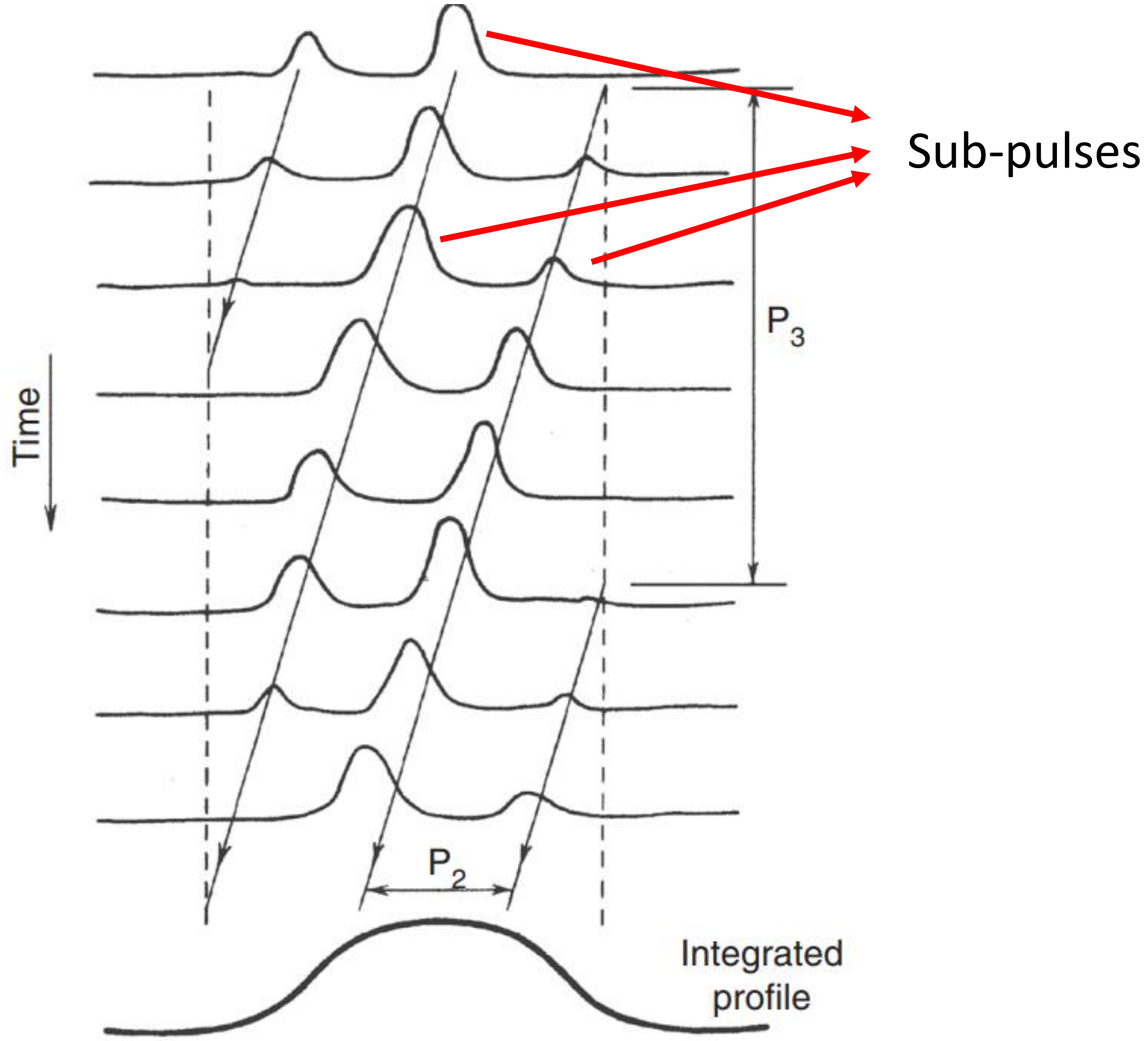
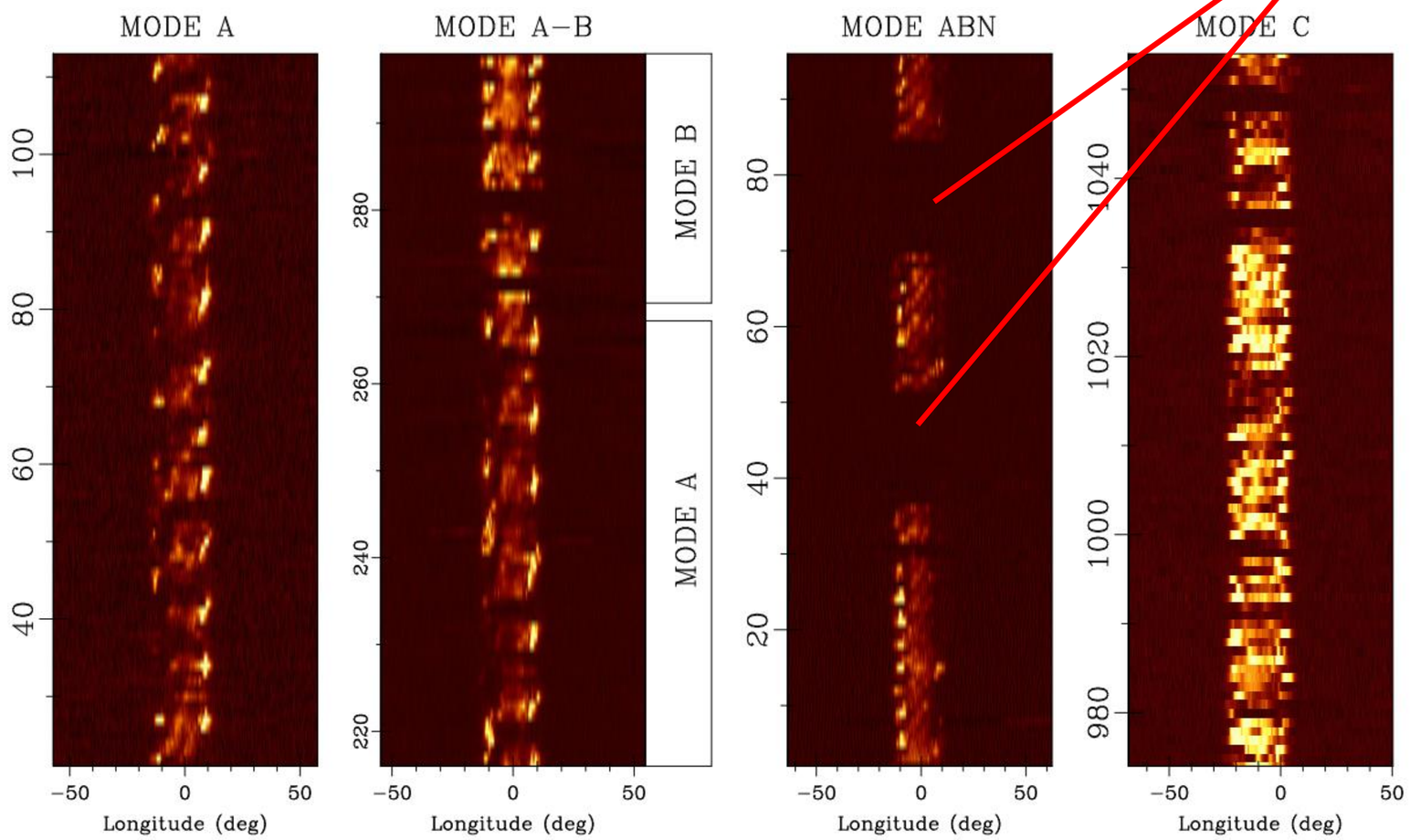
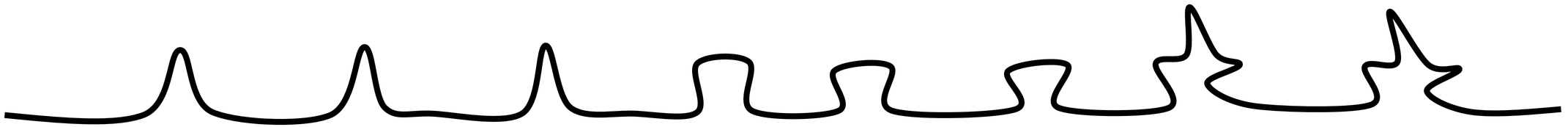


Fig. 16.6. An idealised pattern of drifting sub-pulses.
From *Pulsar Astronomy*

Nulling and Moding:



From Rahaman et al. 2020



Example: Mode 1 Mode 2 Mode 3

Modulation and drifting:
Modulation period on spinning period
Sub-pulse drifting: a kind of modulation

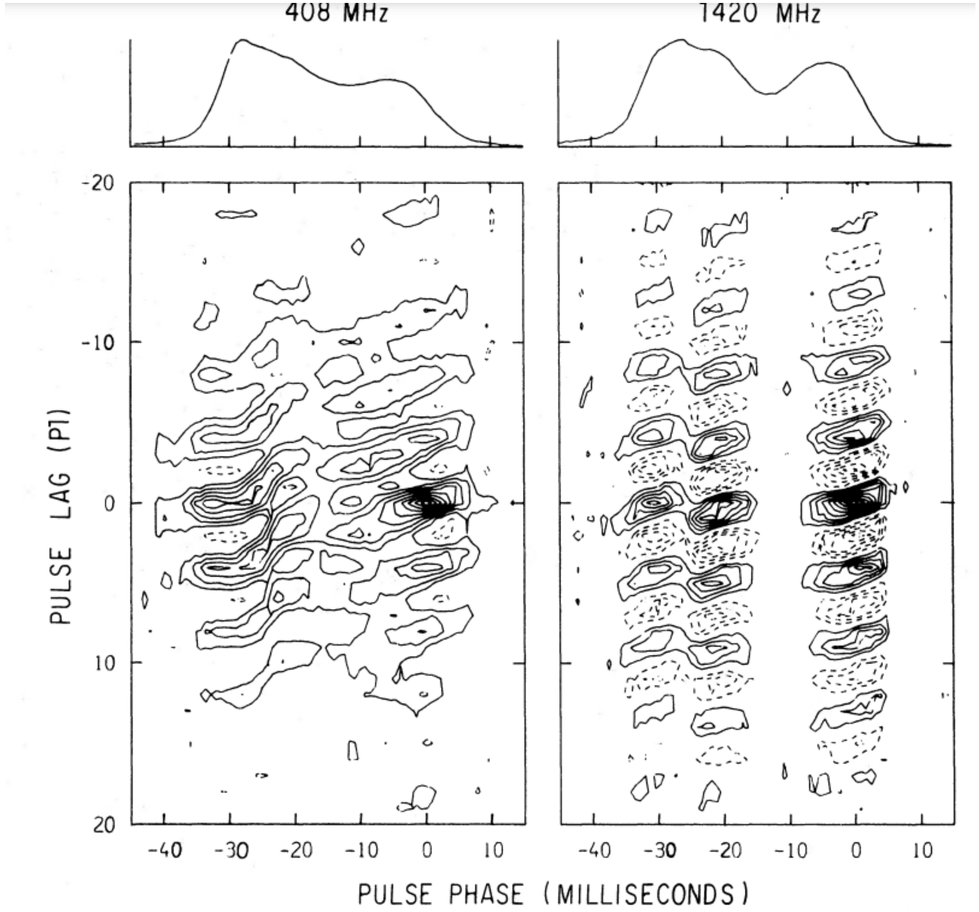


FIG. 3.—Subpulse drift patterns of PSR 1919+21 at 408 MHz and 1420 MHz (for details see caption to Fig. 1)

From Prószynski & Wolszczan 1986

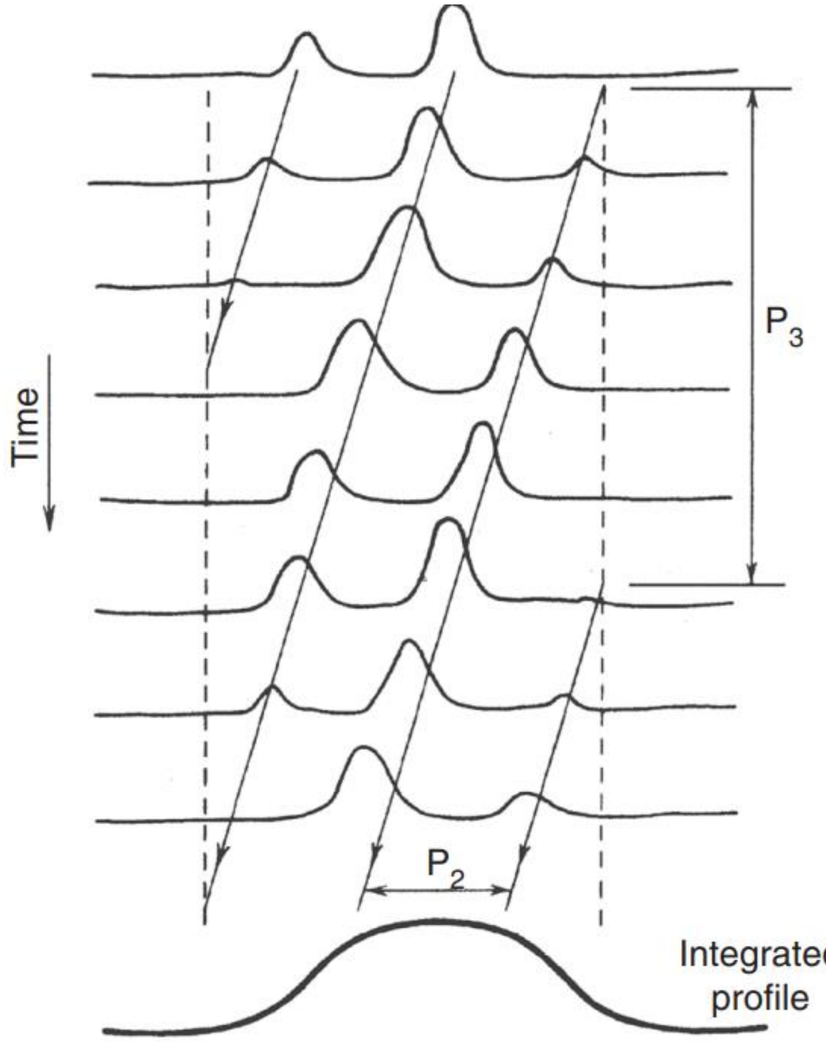
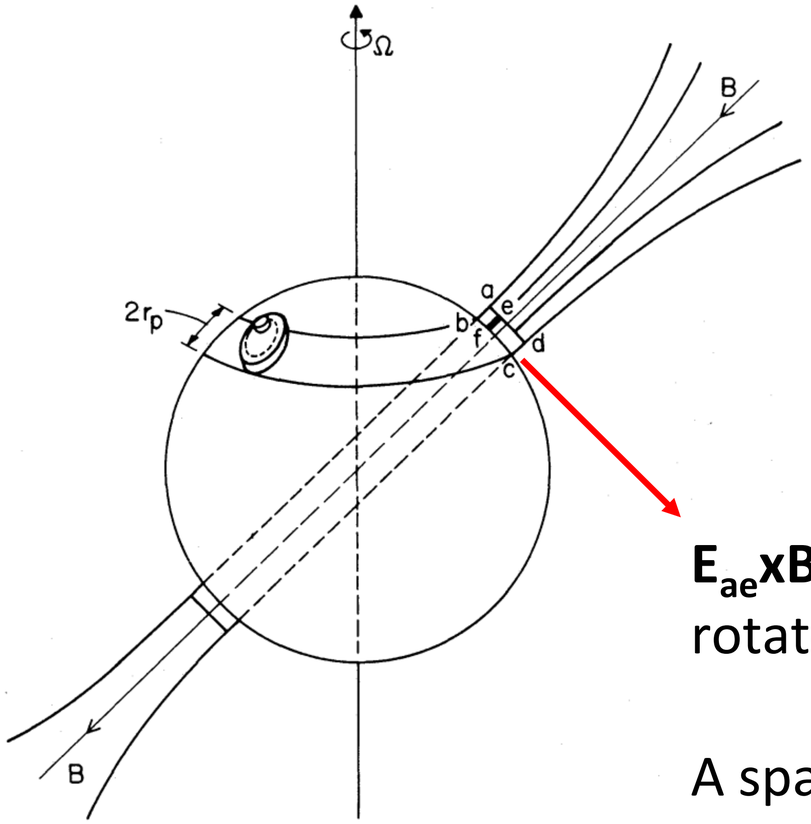


Fig. 16.6. An idealised pattern of drifting sub-pulses.

From *Pulsar Astronomy*

Popular model: RS Model(Ruderman & Sutherland 1975)

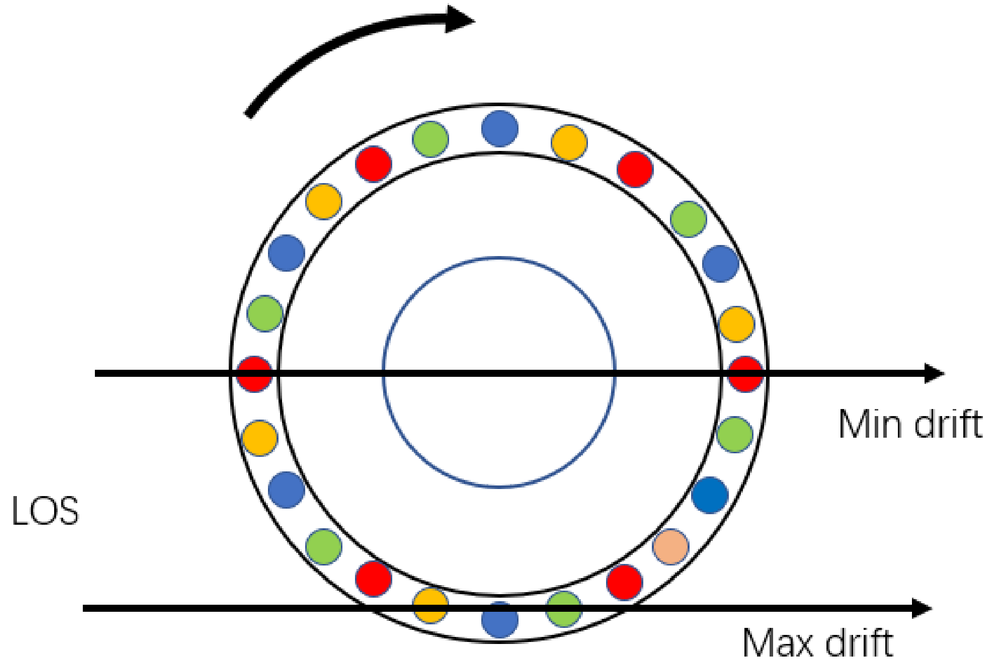
Vacuum gap on polar cap➔➔➔**E·B**≠0, particles accelerated ➔➔➔Vacuum destroyed, sparks appear, bunches of particles moving along magnetic field lines and radiate.



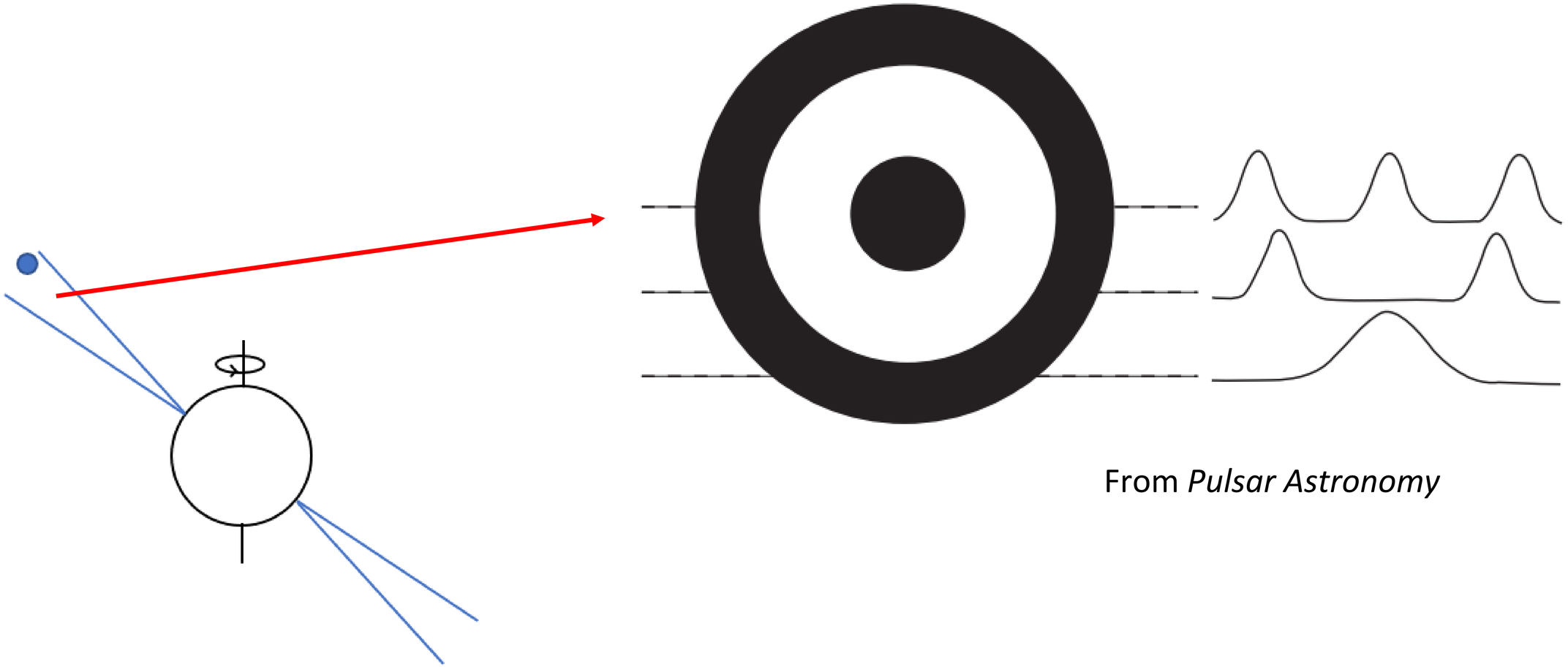
From Ruderman & Sutherland 1975

E_{ae}xB makes sparks rotate. Period **P_d**.

A spark ⇔ A sub-pulse



Popular model: Core-cone radiation beam (Backer 1976, Rankin 1983……)



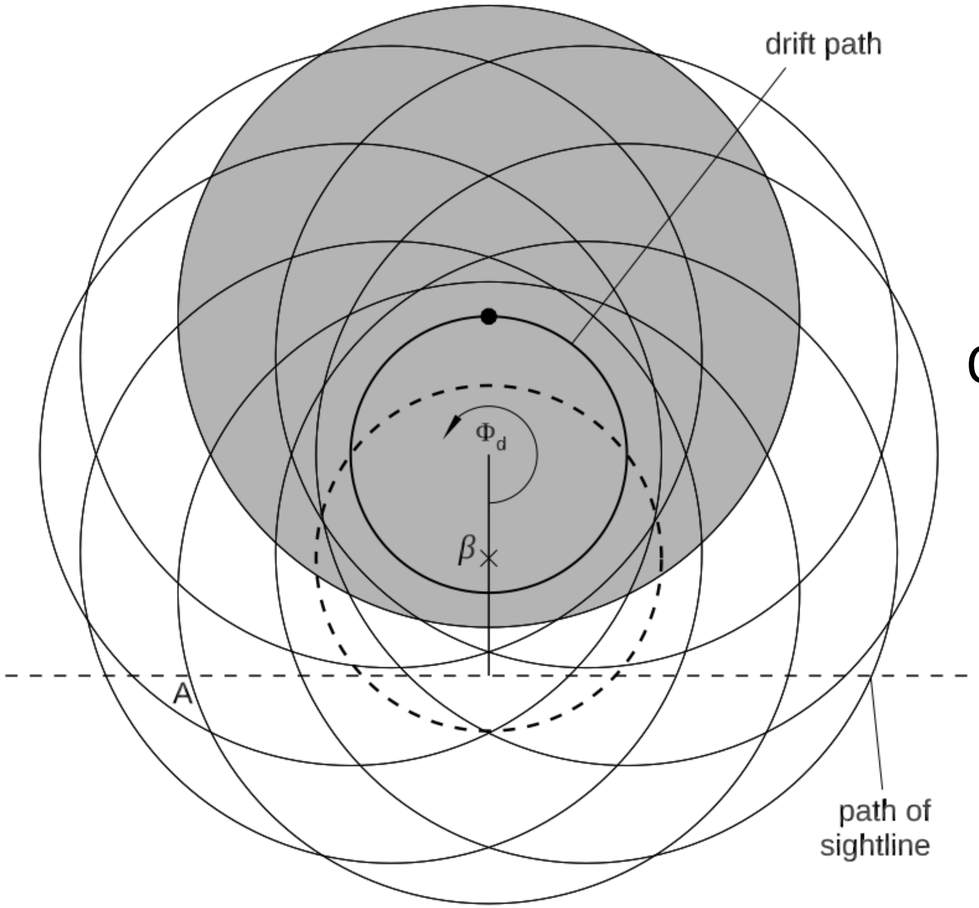
From *Pulsar Astronomy*

Popular models above consider symmetric radiation cones, or in Dyks's words "axially symmetric carousel of sparks " (Dyks, 2021).

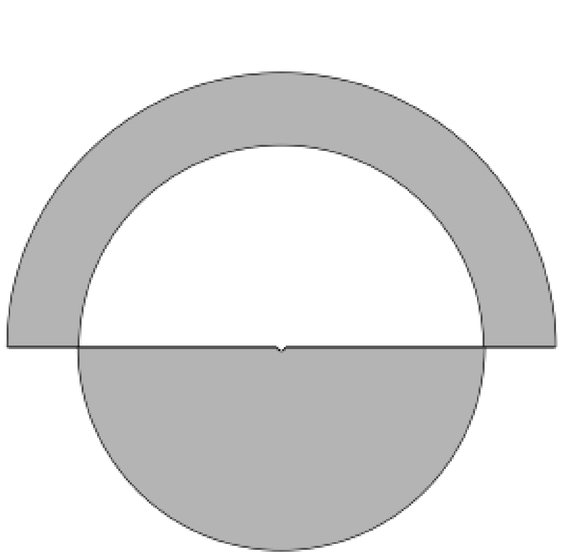
Dyks considers an antisymmetrically zonal radio beam, and thus makes some new discussion.

II. Dyks' model

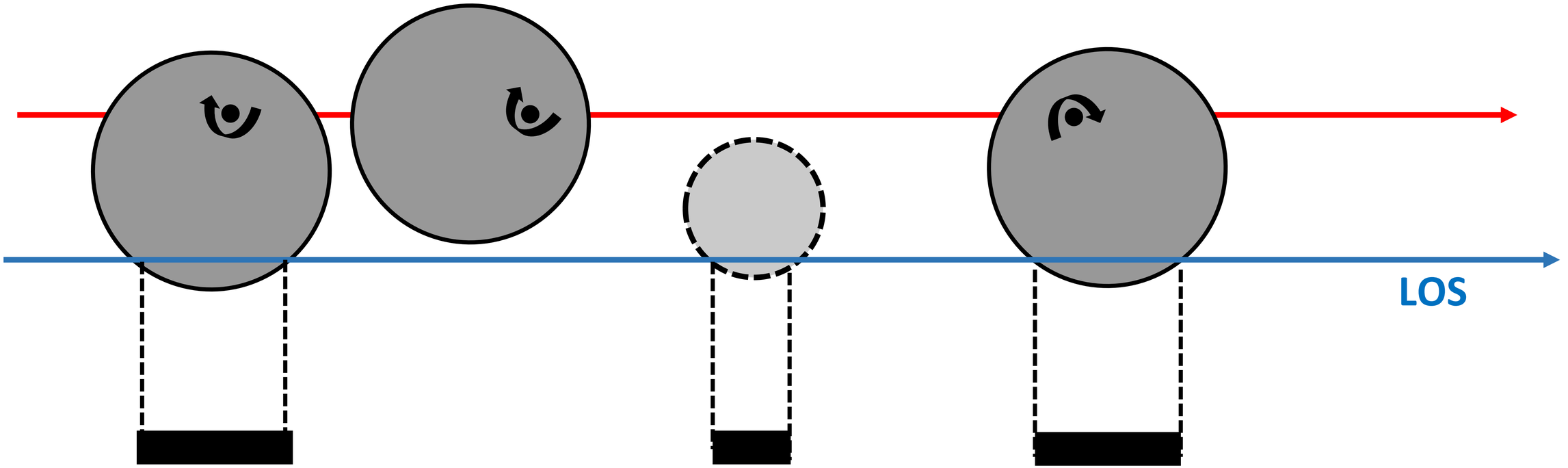
Formation of an antisymmetrically zonal radio beam:

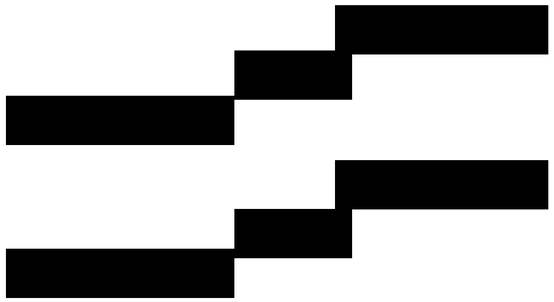


Only crucial features

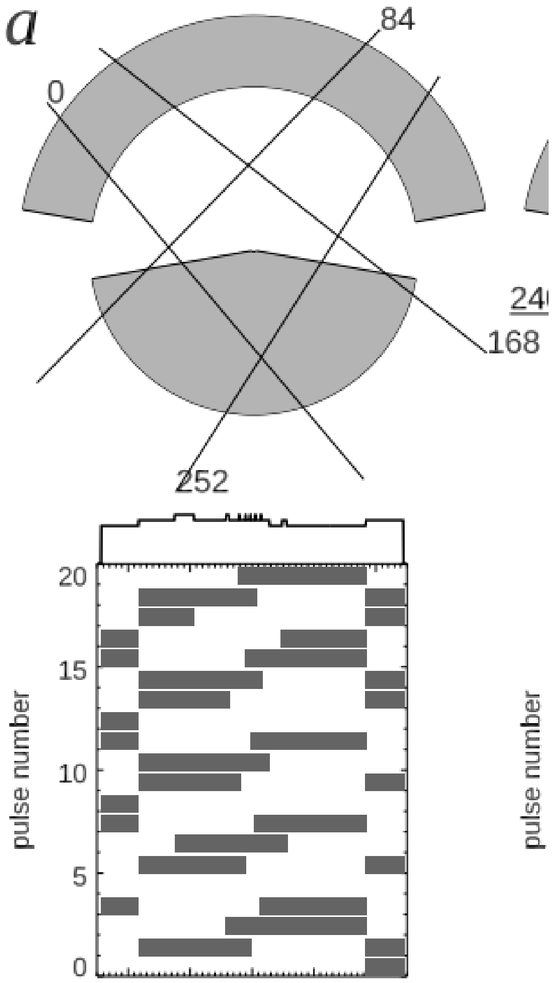


Dyks, 2021


LOS



Line of sight + Beam ➔ Pulses' pattern: half circle jumps



Dyks, 2022

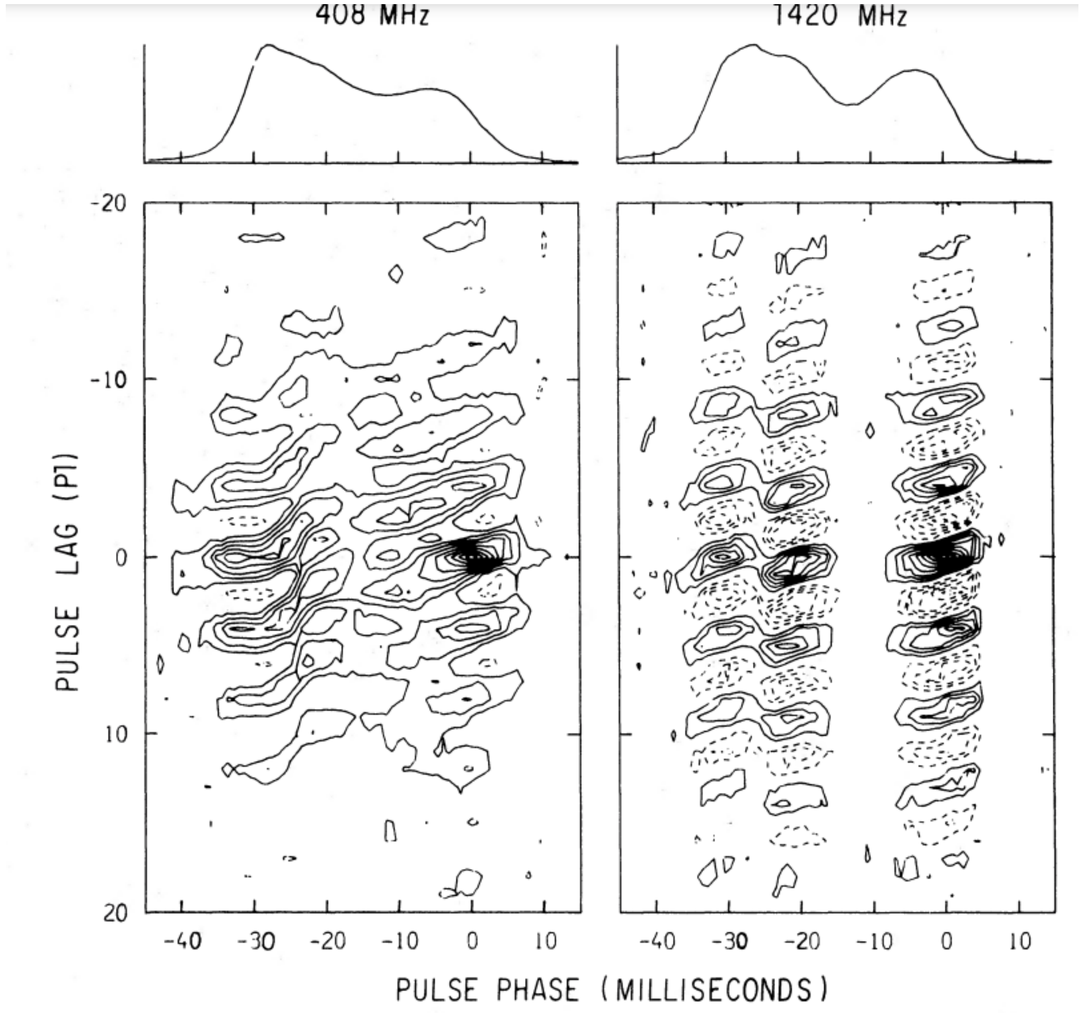
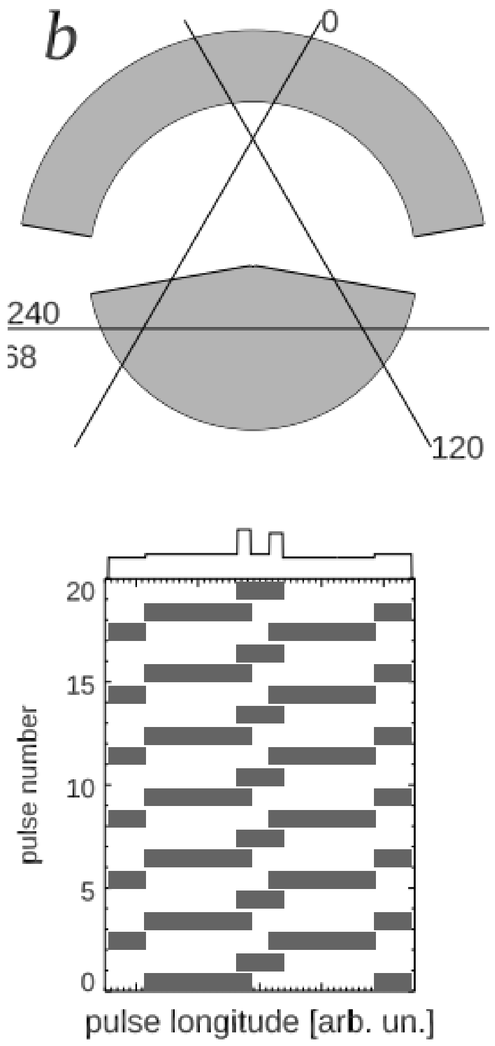


FIG. 3.—Subpulse drift patterns of PSR 1919+21 at 408 MHz and 1420 MHz (for details see caption to Fig. 1)

From Prószynski & Wolszczan 1986

B1919+21

Line of sight + Beam ➔ Pulses' pattern: left-right-middle sequence



Dyks, 2022

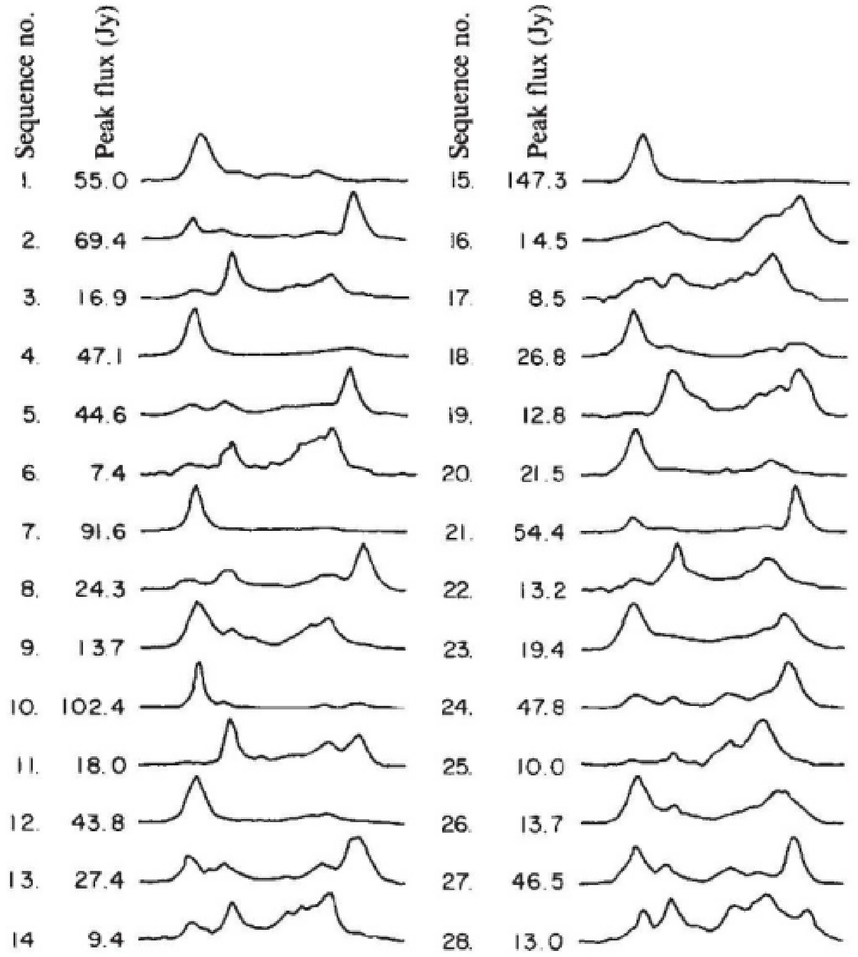
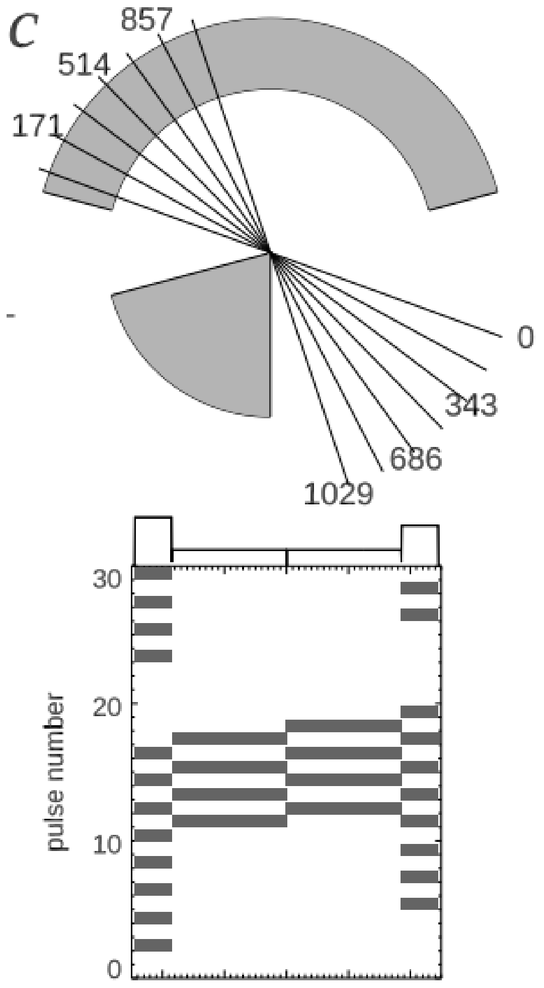


Fig. 2 28 consecutive pulses showing 10 complete S-bursts

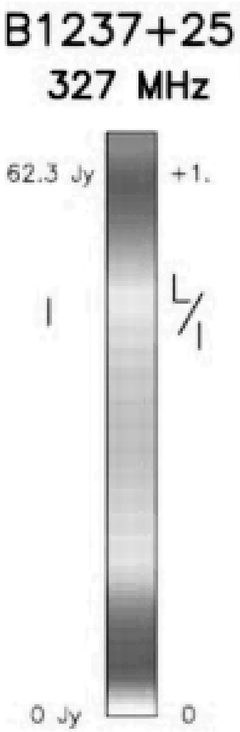
Hankins & Wright, 1980

B1237+25

Line of sight + Beam ➔ Pulses' pattern: transitions between cone-dominated and core-dominated, as well as nulling



Dyks, 2022

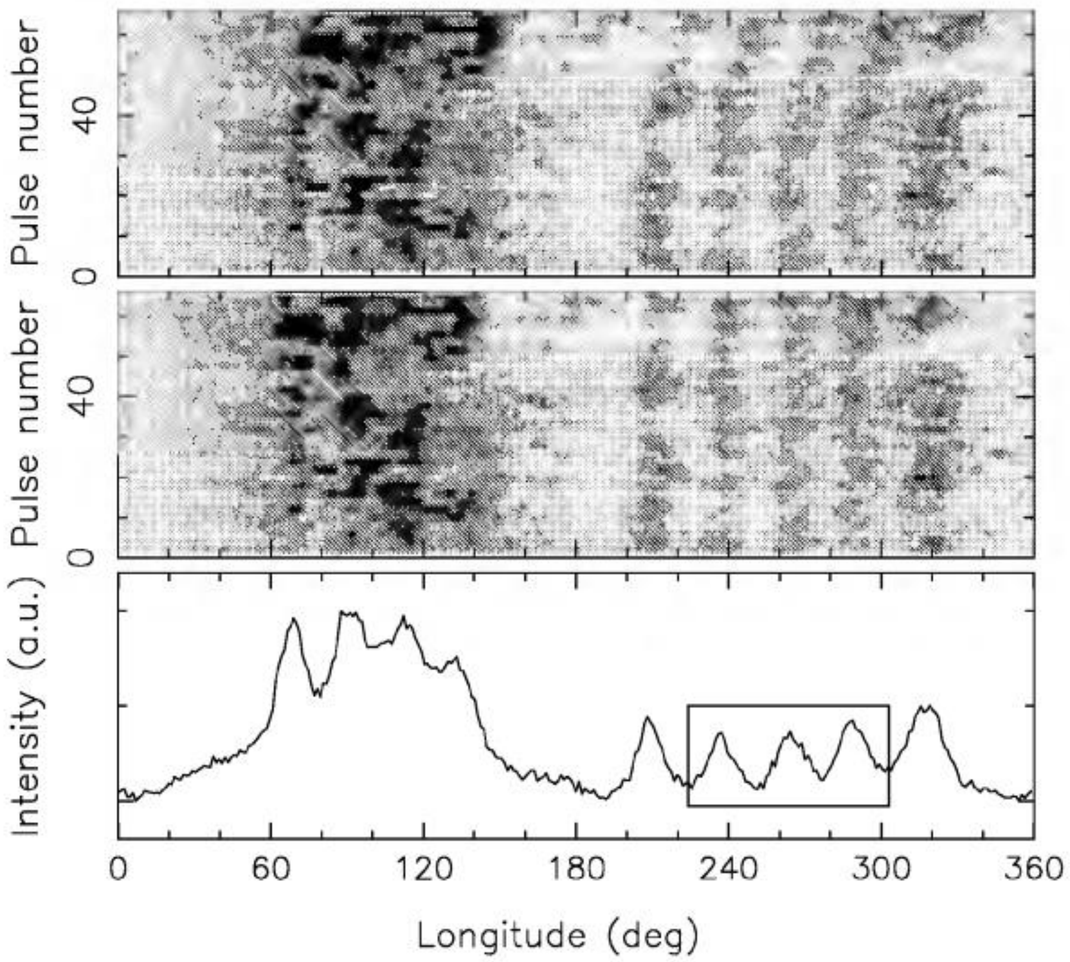


Srostlik & Rankin 2005

Last two pages’ phenomena are all happened on B1237+25.

➔➔➔P_d and beam shape could change.

For B0826-34: low-flux minima between the main pulse and inter-pulse.



Esamdin et al. 2005

Two kinds of beam model:

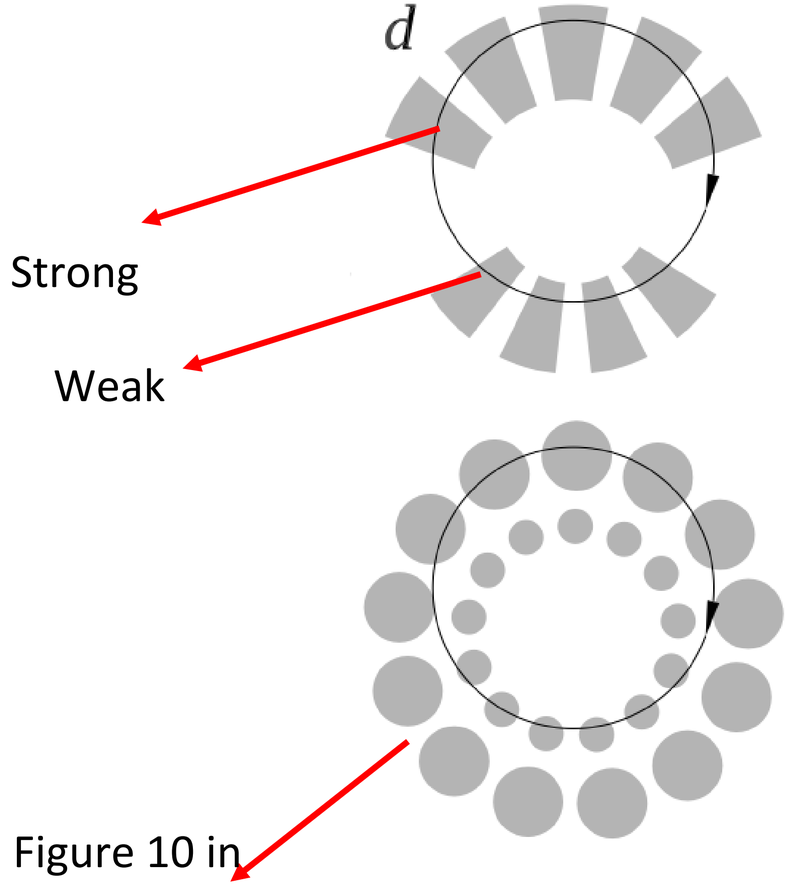
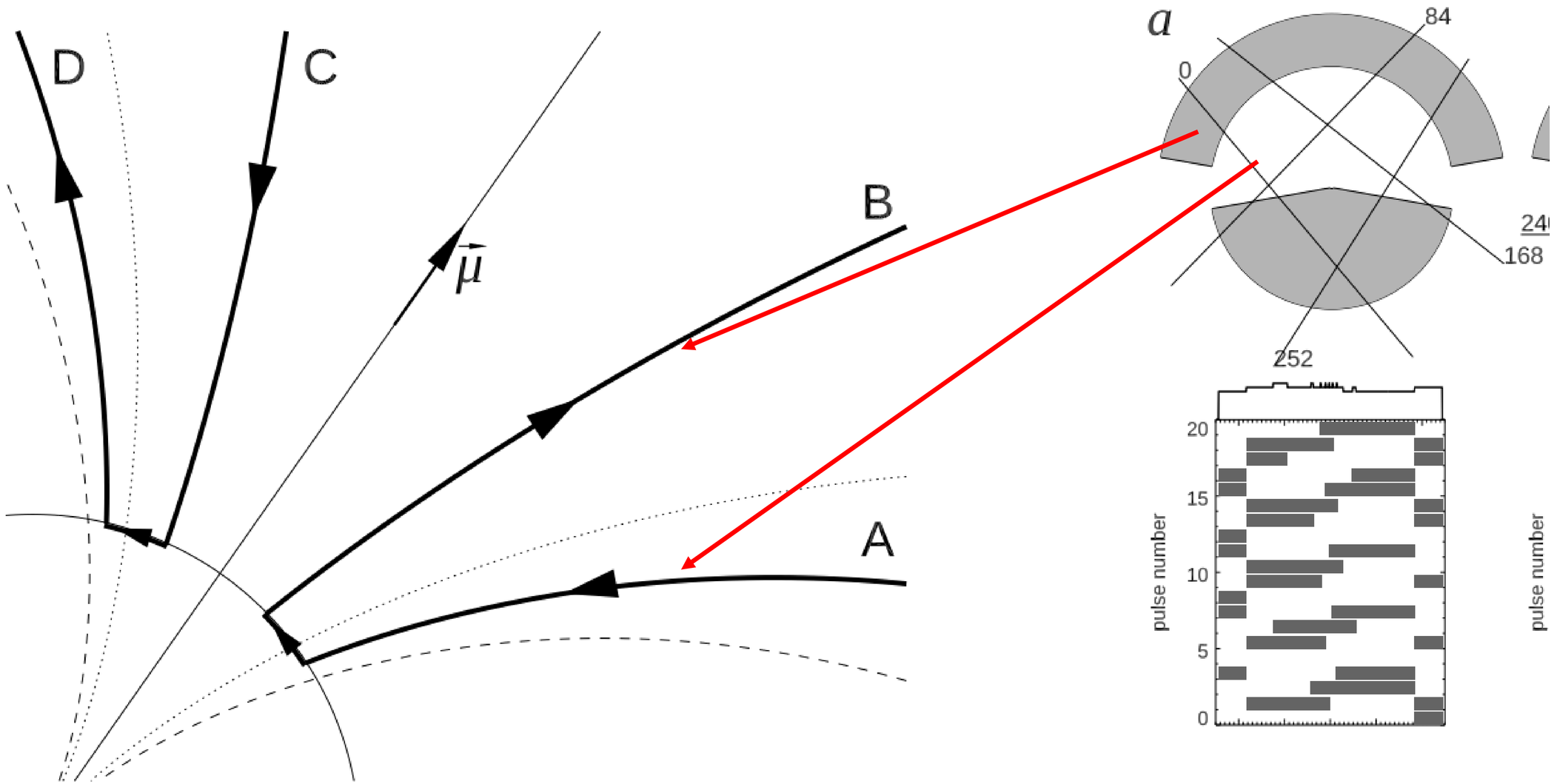


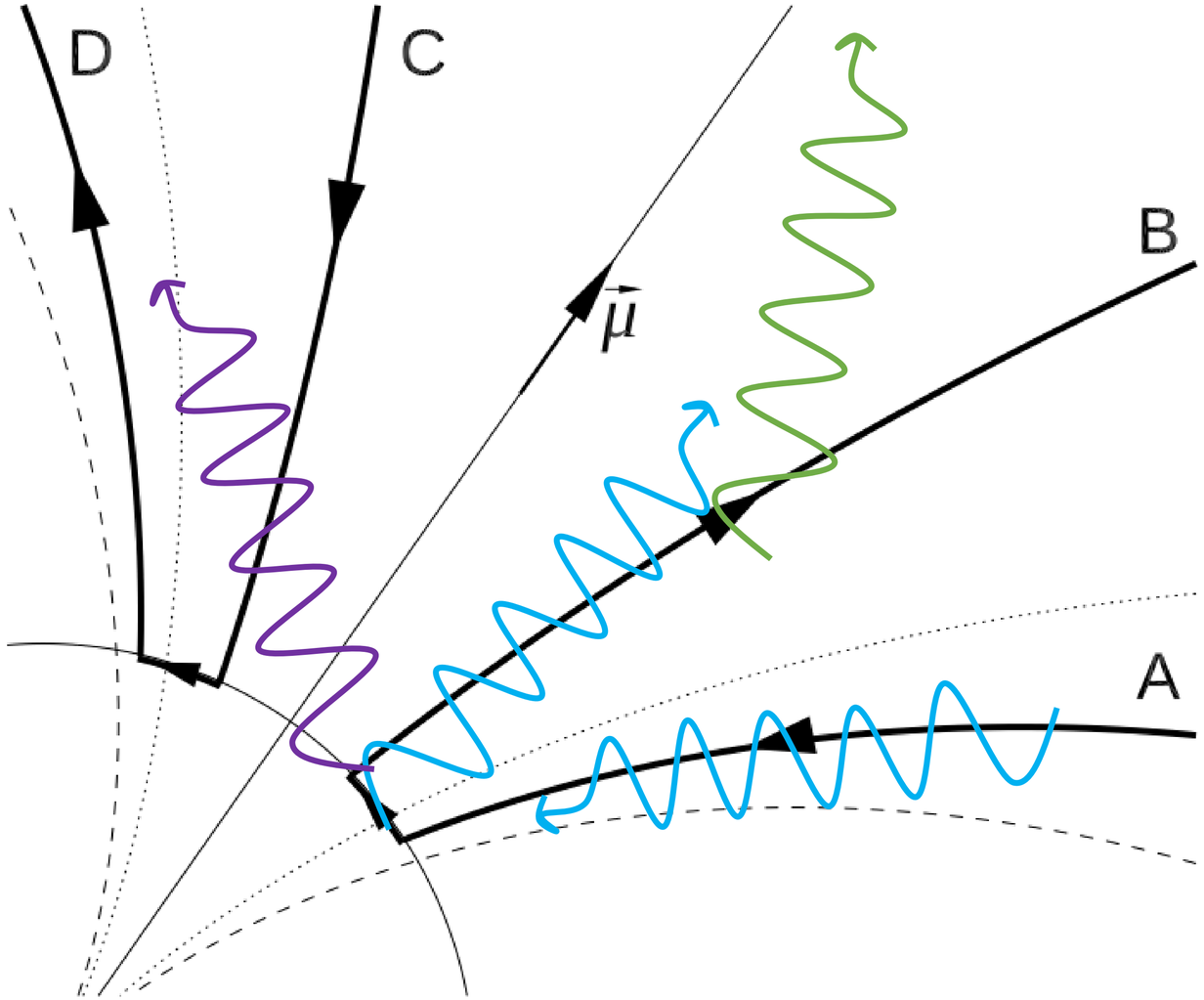
Figure 10 in
Esamdin et al. 2005

Dyks, 2022

III. Discussion： Particles’ flow



Dyks, 2021



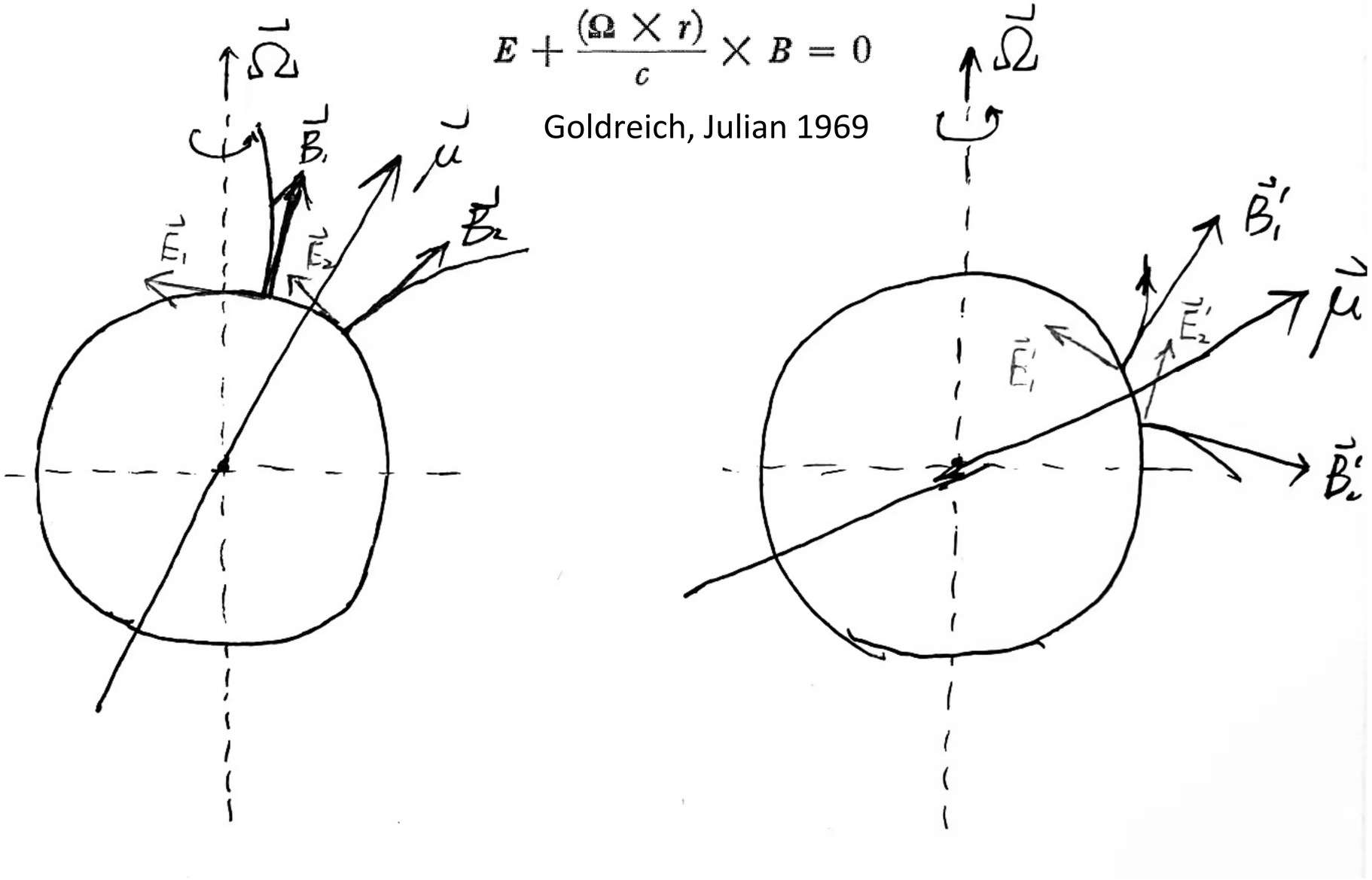
Off pulse beam

Dyks, 2021

How can particles flow like that?——Different direction of **E**

$$E + \frac{(\Omega \times r)}{c} \times B = 0$$

Goldreich, Julian 1969



IV. Conclusion:

Particles’ flow may form a asymmetric radiation rotating beam, which could give explanation to many kinds of single pulses pattern.

Thank you
for your attention